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This report is phase two of a study concerned with environmental and cultural impacts of the proposed channelization of the Trinity River. It consists of a survey of the remainder of Trinity River from Fort Worth to the headwaters of Wallisville Lake below Liberty, Texas. The following subjects are contained in this report: archaeological and historical aspects, inventory survey of geological elements, eutrophication and pesticide elements, biological elements, inventory and checklist of fishes of the Lower Trinity River

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20. drainage system, summer birds and mammals inhabiting the Trinity River, and forest hydrology and conceptual land use capabilities.

A SURVEY OF THE
ENVIRONMENTAL AND CULTURAL RESOURCES
OF THE TRINITY RIVER

by

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Fort Worth District
Fort Worth, Texas

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September 1, 1972

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A

PREFACE

In September, 1971, Stephen F. Austin State University began a study for the Corps of Engineers concerned with environmental and cultural impacts of the proposed channelization of the Trinity River. The study, undertaken in accordance with the National Environmental Policy Act of 1969, consisted of two phases: the first phase was a survey of the site of the proposed Tennessee Colony Reservoir and the second phase was a survey of the remainder of the river from Fort Worth to the headwaters of Wallisville Lake below Liberty. The final report of the Tennessee Colony survey was submitted to the Army Corps of Engineers on January 31, 1972. This report completes phase two of the study.

ACKNOWLEDGEMENTS

The authors are grateful for the support of many administrators and professors at Stephen F. Austin State University during the studies. In particular, Dr. C. R. Voigtel, Director of Development, was most helpful with administrative details.

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To Mrs. Susan Florence fell the major task of typing, correcting, and assembling the report as well as tolerating the eight of us. We thank her.

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CHAPTER I

ARCHAEOLOGICAL AND HISTORICAL ASPECTS OF THE TRINITY RIVER DEVELOPMENT

by

Archie P. McDonald

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INTRODUCTION

Since first coming to Texas, Indian, European, and Anglo-American migrants have been forced to deal with rivers. Indeed, peoples of all lands interact with navigable and serviceable bodies of water. They use rivers as interested riparians, or cross them as disinterested geographical impedimentia which block them from some other goal. The first may be termed a vertical, and the latter a horizontal use. The American migratory trends are good examples of these types of interactions. Moving across the continent, rivers were usually in the way and ferrage or bridging was required to complete the journey; moving up and down the country, rivers were usually useful avenues of transport. They were cheap and mostly uninhibited by political obstructions, but many had rafts, snags or other blockages that needed to be removed. Most Americans would say that the vertical interaction was north-south and that horizontal interaction was east-west. Of course, rivers are not interested in compass points, and water usually flows downhill regardless of the magnetic poles, but the ordinary cultural context is to think of moving water along such lines. A glance at the map of the United States or of Texas will explain why. The Mississippi River, which commands the drainage of mid-America, flows almost due south from its juncture with the Ohio River near Cairo, Illinois, and in Texas nearly all rivers eventually flow southward into the Gulf of Mexico. Along their courses they offer an abundance of usable water (personal, urban, or industrial), camp and ultimately town sites, and life-giving powers to agricultural investment radiating in every direction from the main stream. Looking northward from the Gulf, many offer a navigational potential for the inland communities that are already developed or will be developed along their paths.

The Trinity River is a classic study of this national tableau and is an important part of the mosaic that makes up the whole. Since the first migrants, the Paleo-Americans or "old people," arrived, through the American Indians to Anglo-Americans, it has accommodated the pattern.

The Trinity River rises in four north central Texas counties, Grayson, Montague, Archer, and Parker counties, in what are called forks, namely, the East Fork, Elm Fork, the West Fork and the Clear Fork. The main stream begins with the junction of the Elm and West Forks at

Dallas. From its headwaters it snakes 548 miles to Trinity Bay, or the upper end of Galveston Bay. Its watershed, or drainage area, covers 17,845 square miles, and its width varies from a few feet in the north to a substantial girth near its mouth. The river begins in the section known as the Cross Timbers. It drains portions of the Grand Prairie and the Blackland Prairie, flows across the Post Oak Belt, the Piney Woods Region and finally the Gulf Coast Plain. Over a substantial period of time its flow has gathered sufficient soils to have established a true delta with distributaries of sufficient size to cut off at least partially that part of the bay known as Turtle Bay. Viewed culturally, the Trinity River has been a traditional division line between East Texas and Central Texas. Not far from its western bank the pine and hardwood growth and red soils which characterize the eastern area give way to rolling, virtually treeless plains with a much darker, even black soil, which supports a different immigrant group who generally follow different occupational callings.

From the time of the earliest Anglo-Americans at least, men have schemed to utilize its channel as an inexpensive avenue to and from the interior. First they utilized the force of the river itself as they plyed it southward on flatboats or other craft which brought goods down to Anahuac or Galveston for sale; later steam powered craft were used to go up the river to take in trade goods and bring out cotton and other produce. The narrow channel, rail and later motor competition, and other factors dimmed the dreams of early developers by the 1880's, but the twentieth century produced another dream--making the channel able to bear heavier barge and other water craft that would make such inland communities as Dallas and Fort Worth port cities. Modern engineering techniques could make this possible, but it would be expensive and it would be full of political and later environmental hazards. Several organizations promoted the development, but much time passed before it became much more than a dream. In recent years many of these problems were overcome, some only to be displaced by others, and a case in point is the current requirement for an environmental impact study prior to construction to determine what, if any, damage to the environment would result.

One important factor in this required study is the cultural environment. Biologists, geologists, and other scientists, whose reports constitute the larger portions of these studies, essentially deal with the present conditions of their respective fields, and they are charged

with determining what change would be wrought by reservoir empoundment of water and channelization of the river. The archaeological and history section, however, must deal with a more nebulous and illusive factor--people--and it must deal with them in the past. No environmental impact statements were required of them when they first encountered and dealt with the river. Their use, and occasional misuse, of the river has left its own kind of record, and it is with this that the present study will deal.

For convenience, man's encounter with the river may be herein subdivided into the following general time areas:

A. Pre-historic
B. American Indian
C. European
D. Anglo-American

Each era will be examined separately, with a general summary evaluating the total impact concluding the narrative. Indexes and maps will be included to amplify and illustrate various points.

METHOD

The historical method differs somewhat from the physical sciences, and a brief explanation of methods of gathering and interpreting information needs to be set out. Owing to time and other limiting factors, most of the information provided by this report has been obtained from the following sources:

A. Books and articles in print and available at most of the libraries of the state and nation, ranging from travel accounts of explorers, syntheses of Spanish, French, American, and Texas history, county histories, previous impact reports

B. Maps, including several nineteenth century imprints

C. County historical survey committees and their coordinating state office

D. Published material from various promotional groups

E. Limitedly, from personal observation of the river and some of the sites discussed.

The object has been to gather as much data as possible of man's encounter with the river, and to organize it geographically and chronologically for ease of digestion. Copies of several documents will be provided, some information will be presented in charts, where the information is available a county by county survey of cultural encounters will be cited, and a bibliography of sources will be presented for more complete reference by interested parties.

ARCHAEOLOGY

Archaeological research in the Trinity River Basin has largely been restricted to salvage operations conducted by amateur and professional groups, which has concentrated on chronology building. It is therefore easier to date the time era of sites than it is to speak in detailed cultural terms about the inhabitants of those sites. A broad chronological framework for Texas was presented in 1954 in the "Handbook for Texas Archaeology." In essence, there are four basic periods set out:

Paleo-Indian (9500-5500 B.C.)	mammoth, bison hunting; seasonal movement; small bands composed of several families
Archaic (5500 B.C.-A.D. 800)	hunting of small game, gathering wild plants, seasonal movement; small bands composed of several families
Neo-American (A.D. 800-1600)	hunting and gathering, marginal agriculture in same areas; tribal and confederacy groups
Historic (A.D. 1699-1800)	introduction of horse and eventual extermination or removal of Indians

Looking at these time areas within a geographical framework, that is, timed development of the lower, middle,

and upper river areas, there are several previously published studies which will be helpful and which will be summarized here. In addition, on-site work is continuing in the lower Trinity River area presently under the direction of the University of Texas at Austin's Texas Archaeological Salvage Project. David S. Dibble is the director of the project. In a previous report entitled "Environmental and Cultural Resources Within the Trinity River Basin," assembled by James V. Sciscenti and submitted to the Corps of Engineers, Fort Worth District, through the Institute for the Study of Earth and Man in final fulfillment of Contract DAW63-71-C-0075, the basic archaeological information for the area is expertly set out. Specifically, S. Alan Skinner's section is most helpful to an understanding of the archaeological conditions of the Basin.

In the lower Trinity River area, active archaeological research has been conducted by Rice University, the University of Texas' Texas Archaeological Salvage Project, the Texas State Building Commission, and the Houston Archaeological Society. Sites worked include the Wallisville Reservoir, Addicks Dam Reservoir, Caplen, Cedar Bayou, Jamison, Fullen, and the Nuestra Senora de la Lux mission site. Most are located on or in the contemporary floodplain, and many suspected sites were buried by river flooding. Some are located on or near the present course and would be endangered by extensive excavation. North of the Wallisville area, the most extensive work has been done in the area of the Livingston Reservoir.

In the middle Trinity River area, or from Tennessee Colony to the Livingston Reservoir, no Paleo-Indian or Archaic State sites have been discovered. Instead, the Neo-American, especially represented by the Caddo Confederacy, predominates. Little work has been done in the area, although peripheral reservoir areas have been excavated by federal agencies as salvage projects. See the aforementioned report assembled by James V. Sciscenti. See especially the chapter, "Archaeological Literature Survey of the Trinity River Basin," by S. Alan Skinner, pages 131 to 187.

The upper Trinity River area, like that of the lower area, is somewhat more advanced in this work. In this region it has essentially been conducted by members of the Dallas Archaeological Society, and centered in the Lake Lavon, Garza-Little Elm Reservoir, and Forney Reservoir sites. There are a number of village and camp site locations in the region. The majority occur at the edge

of the Trinity River floodplain, but others may be under the river silt.

In summary, the archaeological work necessary before possible damage by channelization of the river has not yet been completed. Unlike that of the historical periods, when man's record of his interaction with the river was more or less self-kept, this period's work is much less definite. Projects still underway may yet reveal more information about past civilizations that utilized the Trinity River.

AMERICAN INDIAN

As is suggested by the foregoing archaeological section, human interaction with the Trinity River is of relatively recent origin, as geologic time is measured, but is approximately contemporary with other North American human development. In other sections of the country, particularly the southwest, evidences of human presence dating from 10,000 B.C. and even earlier are available if not numerous. But until fairly recent times, little or no evidence existed of any human inhabitation in the eastern portions of Texas that antidate European immigration by any appreciable period of time. How and when such people found their way to the Trinity River region is unknowable, but they were the first of many who ultimately made the trek.

No humans are native to the New World, therefore all who lived along the Trinity River are invaders, or immigrants. The earliest probably began their migrations from Asia after the great glaciers of the Ice Age had absorbed enough of the sea to leave a narrow land bridge; others perhaps came on crude vessels that were carried by natural currents. They fanned out across the North American continent, running from hunger, human enemies, or some other expelling force. They were not Indians in the present sense, but these Paleo-Americans were biologically true men. They had long-headed skulls, massive teeth, and flat and curved leg bones. They were possibly a Caucasoid race that had come eastward from Central Asia. They came with considerable evolution of human and social development behind them. They were erect, gregarious, and were symbol using and weapon using. They understood the use of fire, wore fur and skin garments, and made tools of flint and bone. The flint was fashioned into spearheads that are still being discovered. They may have made flutes and drums, and used them in the

worship of some deity, but little of their culture has survived--with a curious exception. In the oldest trace of the Trinity River, seventy feet above the present flood plain, great stone heads have been discovered, considered by some paleontologists to be among the most exotic human relics unearthed in North America. The heads were discovered among the bones of the Columbian elephant and the great mastodon, and were tooled from rock. One weighed 135 pounds, one 60 pounds, and the third 100 pounds. The first two are obviously human, one smiling, one frowning. The third and largest is not recognizably human. These heads were located in three separate discoveries dating from 1929 to 1939, and were located in the gravel beds north of Malakoff in Henderson County. The largest was 16 inches long and 13 to 14 inches wide. This evidence of early man is different from other artifacts made of flint, and no tools or objects of the hunt or warfare were found in association with these sculptures. Exactly where or when they were made is unknown, but it was likely that they were made at some other place than where they were later discovered in the deposits of the Trinity River.

Another and later discovery on the Trinity River confirms the existence of earlier man. In 1946 the Trinity River levee broke below the Trinidad Power Plant and washed out a buried campsite and uncovered thousands of early artifacts. One peculiar shield-shaped projectile point was later identified by a University of Texas archaeologist, Alex D. Krieger, as an unfluted Folsom. The Folsom culture, named for the discovery near Folsom, New Mexico of the bones of thirty bison buried with the arrowhead and javelin points that had been shot into the animals between 10,000 and 20,000 years ago. The discovery of such a cultural artifact along the Trinity River confirms the probable eastern extension of their migrations.

Whatever environmental milieu that had caused the coming of these early peoples changed, and their departure from the scene was followed by the migrations of the American Indians. Their movements followed the earlier routes, but tended to flow southward toward the narrower passages of Central America, through the isthmus, and then broadened out again across South America. Where geography forced closer contact, higher civilizations developed, including the Inca of northern South America, and the Maya and Aztec of southern Mexico. Most of the Indians in Texas followed the southern routes, but some returned from the area of Mexico to found new

sites in Texas. Guy E. Powell has discovered sufficient artifacts of an Aztec-type civilization to make a serious claim for a settlement in Trinity County just above the site of Sebastopol. Powell claims that seven Aztec cities were located here on or near the banks of the Trinity River in the area drained by South Caney and White Rock Creeks. Other cultures present included the Mound Builders, who erected large piles of earth for ceremonial purposes, reflecting also an Aztec influence.

Such pre-Columbian Indians were present in Texas, but they were few in numbers and their use of the river would have been basic and not disturbing. It represented a source of water for human utilization and perhaps served as a means of transportation. Villages were located along its course, burial areas were probably near by, and day to day use was clearly indicated. But no permanent structures or obstructions were erected, excavated, or implemented. What might be called post-Columbian Indians, or those who were living in the region when Europeans arrived, were equally undisturbing to the river. On the upper Trinity River the Indian group which dominated was the Caddo, or the Hasinai Confederacy. The Caddo lived in small villages, hunted, and grew vegetables. Their houses were comfortable, and furnished with pottery, baskets, and bright colored rugs. They made bows of the abundant woods of their forests and used these as trade items with the plains Indians. The Caddo, unique among Indians, shed tears easily. They dressed mostly in tanned deer skins which were usually fringed with small seeds that were pierced and sewn on. Since they were agriculturalists, they seldom were at war with anyone. They raised corn, beans, squash, sunflower seed and tobacco with crude implements. Their only domesticated animal was the dog. They built temples for worship, and sometimes built them on the mounds that were still apparent. They were especially adept at fashioning varied pottery, and were skilled in other handicrafts.

South of the Hasinai Caddo, on the lower Trinity and other rivers, were the Bidai, Deadose, Orcoquisac, and Attacapa tribes. Westward from the Trinity River along the coast dwelt the Coco, Cujane, Karankawa, Coapite and Copane. The Atakapan Indians were less attractive to modern man than were the Caddoes. Their name means "maneaters" or "cannibals" in the Choctaw language. They were never numerous, and in their various segments hardly constituted more than 35,000. They were composed of the Bidias upstream on the Trinity River, and the Akokisas or Orcoquisac on the lower

Trinity River. They were hunters, gatherers and fishermen, and they utilized the game of the region for food and its fur for clothing. They were very dark skinned, with dirty, short, coarse black hair, with stout bodies, and they were rather short. The head was usually large with most of the features on an appropriate scale. An Orcoquisac village, and later a Spanish mission to serve them, was located on the east bank of the Trinity just above Anahuac at Wallisville near the dam site. This will be discussed in greater detail in the European section.

To the north in the Trinity-Polk-Tyler county region, the Coushatta Indians made their home. Their principal dwelling was on the east bank of the river south of the Spanish community of Salcedo in the vicinity of Kickapoo or Onalaska. Here they cultivated corn and beans. Today the Alabama and Coushatta Indian Reservation is located in Polk County between Livingston and Woodville. The reservation and their traditional hunting grounds lie within the area known as the Big Thicket, which stops just short of the river. These Indians moved into the region after 1800 from the vicinity of the Mississippi River. Generally regarded as friendly Indians, they were given the reservation on state owned land in 1854.

The only other significant Indian interaction with the river occurred to the north in the Forks region. Here the Cherokee Indians, after being forced off other lands to the south and east, took refuge in the headwaters of the Trinity River. Their leader, Chief Bowles, had been killed in these actions and his son John plus another Indian named Egg ultimately hoped to escape into New Mexico. Several military clashes were precipitated by their presence, however, which resulted in considerable loss of Indian life in 1839. In 1843 a treaty was signed at Bird's Fort, seven miles north of the present town of Arlington, that brought peace to the area. The fort was named for Jonathan Bird, and it was situated near the river along the road from the Red River to Austin. The treaty was negotiated by Sam Houston.

In summary, the Indian interaction with the Trinity River left no significant marks. There were a number of villages and campsites situated near or on the river, and even burial grounds. Most of their artifacts and human remains have been discovered accidentally by other human and natural causes, such as the Orcoquisac remains near Wallisville which were discovered when gravel was excavated for a road bed, or by flood action which unearthed

Map 2. INDIAN VILLAGE SITES AND INDIAN TRAILS.

(White numbers on black background refer to village sites. Villages numbered 1 through 8 existed prior to 1835; numbers 9 through 11 were established after 1835.)

1. Peachtree Village
2. Flea Village
3. Fenced-in Village
4. Battise Village
5. Long King's Village
6. Colita's Village
7. Campground (probably used by both Alabamas and Coushattas)
8. Village of the Pacana Muscogies (Creeks) on the John Burgess League
9. Barclay Village
10. Rock Village
11. Alabama-Coushatta Reservation; consists of 1,110.7 acres granted by the state of Texas to the Alabama Tribe in 1854 and 3,071 acres purchased by the federal government in 1928 for the Alabama and Coushatta tribes.

(Black numbers on white background indicate towns and communities. These are shown as geographical reference points. All except Fort Teran were established after 1835.)

12. Fort Teran
13. Livingston
14. Moscow
15. Woodville
16. Smithville
17. Swarthout
18. Onalaska
19. Goodrich

(Black letters on white background indicate trails that existed prior to 1835.)

A. Coushatta Trace–from a Coushatta village on the Sabine River to the Colorado River south of Columbus

B. Long King's Trace–from Peachtree Village to a point near the western boundary of San Jacinto County, where this trail merged with the Coushatta Trace

C. Alabama Trace–from the San Antonio Road east of Nacogdoches through Peachtree Village and the site of the present Alabama-Coushatta Reservation to Colita's Village on the Trinity River

D. Liberty-Nacogdoches Road–originally used by the Spanish in trips between Nacogdoches and the mouth of the Trinity River; later extensively used by the Alabamas and Coushattas

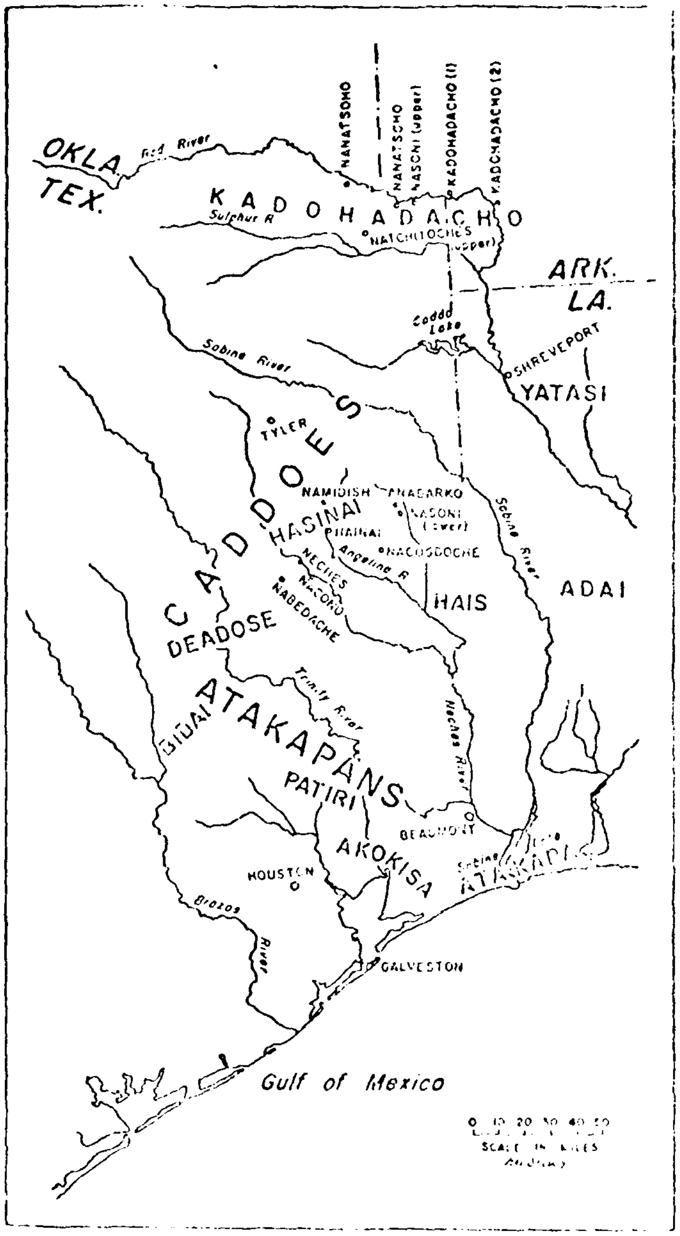
E. Kickapoo Trace–from the Battise Village on the Trinity River to the Kickapoo Indian Village near Palestine

F. Battise Trace–from the Battise Village to Long King's Village

G. Colita's Trace–from Colita's Village to Long King's Village

H. Long Tom's Trace–from Long King's Village to the Long Tom Creek area

I. Campground Trace–from Long King's Village to the campground south of the present Alabama-Coushatta Reservation


OKLA.
TEX.
Red River
NANATSOHO
NANATSCHO
NASONI (upper)
KADOHADACHO (1)
KADOHADACHO (2)
KADOHADACHO
Sulphur R.
NATCHITOCHES (upper)
ARK.
LA.
Caddo Lake
SHREVEPORT
YATASI
Sabine River
TYLER
CADDOES
NAMIDISH
ANADARKO
NASONI (lower)
HAINAI
HASINAI
NACOGDOCHE
Angelina R.
NECHES
NACONO
NABEDACHE
HAIS
ADAI
Sabine River
DEADOSE
BIDAI
ATAKAPANS
Trinity River
PATIRI
Neches River
BEAUMONT
AKOKISA
Sabine Lake
ATAKAPAS
HOUSTON
Brazos River
GALVESTON
Gulf of Mexico
0 10 20 30 40 50
SCALE IN MILES

the Folsom point. Some deliberate search has produced the Aztec and Malakoff finds, and some Indians still live in the region, providing living examples of their cultural ancestors.

EUROPEANS

The history of Europeans in Texas and especially in conjunction with the Trinity River begins in 1519 when the expedition of Alonso Alvarez de Pineda explored the Gulf Coast. Pineda was acting on orders from Governor Garay of Jamaica to explore the Gulf from Florida to Vera Cruz. His reports to Garay were encouraging, and the Governor sent several unsuccessful expeditions to establish settlements. The next documentable European interaction with Texas, again Spanish, involved Alvar Nunez Cabeza de Vaca, a member of an expedition led by Panfilo de Narvaez. The expedition became stranded in Florida and there they constructed five small vessels to try to make it to Mexico. Only four of the men ever reached their destination. Cabeza de Vaca's vessel was wrecked on Galveston not far from the mouth of the Trinity River in November, 1528. For the next few years he lived as a semi-captive of the Indians, and he was protected because they believed him to possess faith-healing powers. After meeting other survivors of the original expedition, he finally made his way overland to Mexico. They had seen no gold or silver, but they heard many stories from the Indians which were related to the authorities, and their desire to locate these precious minerals stimulated other expeditions. Mendoza, the viceroy of New Spain, sent one of the survivors, a black named Estavanico, or Stephen, with Friar Marcos de Niza to confirm the stories of gold. In 1539 they marched northward. When they reached the pueblo Cibola, they believed that they had found a city of gold. Stephen was killed there, but the padre hurried back to Mendoza with the news he knew his governor wanted to hear, hoping that it would cause other entradas and the establishment of ecclesiastical missions to the Indians.

Marcos' stories were sufficient to increase the interest of the Spanish in the regions of the north, and in 1540 a new expedition was dispatched to locate the cities of gold. Vasquez de Coronado, governor of Nueva Galicia, was chosen to lead the expedition. Their journey north reached as far as present-day Kansas, with patrols reaching into Nebraska. They discovered the Grand Canyon and performed valuable exploration and map work of the

interior of North America, but they found no gold. On their way back to Mexico they passed close by the headwaters of the Trinity River, but probably did not actually sight them.

Farther to the east, another Spanish expedition was on the march at about this same time. Led by Hernando de Soto, this group moved northward out of Florida, also seeking gold. They made it to the area west of the Mississippi River where de Soto died. Command of the group was then assumed by Luis de Moscoso, who eventually led some of the survivors first overland and then by boat to Mexico.

These early expeditions failed to produce the precious metals that stimulated Spanish expansion, and for a number of years their interest in Texas was very slight. It would later be restimulated by the activities of the French which the Spanish regarded as jeopardizing to their claim and interests. The first French activity in Texas was led by Rene Robert Cavelier, Sieur de la Salle. In 1682 he travelled from New France down the Mississippi River to its mouth and claimed its drainage area for his sovereign, Louis, calling it Louisiana. Two years later he determined to return to the area with 400 settlers to establish a colony on the Gulf of Mexico. Either by accident or design he landed far to the west of his destination, coming into Matagorda Bay on the Texas coast in February, 1685. There he founded a colony, Fort St. Louis, which never prospered. In 1686 he explored inland as far as the Trinity River, and the following year he led a group northeast trying to find French settlements on the Mississippi for relief of his despondent colony. Along the way he was murdered by his own men. Although not intrinsically successful, the French efforts did stimulate further Spanish activity in the region. Alonso de Leon led several of the eleven Spanish attempts to locate and destroy the French invaders. De Leon's fourth expedition was successful in 1689. They located Fort St. Louis, but learned that it had already been destroyed by Indians. The friendliness of the Indians north of the fort plus the fear of renewed French activity, caused the Spanish to establish several missions in the north and east sections of Texas. In 1690 they founded the mission San Francisco de los Tejas not far from the Neches River, near the village of Weches, in present Houston County. In their travels in the region the Spanish crossed and named the Trinity River. De Leon called it the *Rio de la Santisima Trinidad*, or the River of the Holy Trinity. The Spanish established

several permanent crossings of the river while on this expedition. The following year Domingo Teran de los Rios led another party into the area and founded the mission Santisimo Nombre de Maria. Neither of the missions succeeded very long, and Spanish investment in Texas once more was allowed to drop.

However, the arrival of another Frenchman revived it. Louis Juchereau de St. Denis came in 1705 to establish trade relations with the Indians. He operated from a base in Natchitoches for a number of years, and in 1714 travelled all the way to the Rio Grande without seeing a Spaniard. The road he pioneered, the Old San Antonio Road, was used by the Spanish to connect missions and presidios. It crossed the Trinity River in Madison County, not far from Midway. As a modern highway, portions of the road are still in use. St. Denis was then taken to Mexico City, where he married the granddaughter of Diego Ramon, a Spanish official. St. Denis' activities in Texas needed to be compromised by the Spanish, so in 1716 he accompanied Ramon on an expedition to more obviously establish the Spanish presence in Texas. They established the missions San Francisco de los Neches; Purisima Concepcion, near Linwood Crossing on the Angelina River; Nuestra Senora de Guadalupe, on the site of present Nacogdoches; San Jose, in the northern part of Nacogdoches County; San Miguel de Linares, in Louisiana; and Nuestra Senora de los Delores de los Ais, near San Augustine; and a presidio for troops, Nuestra Senora de los Delores. Again, most of these missions were short lived, and by 1730 most of them were removed and re-established in the San Antonio region.

Spanish settlement of the Trinity River region began in mid-eighteenth century. Again, it was in response to French activity, this time near the mouth of the Trinity River, especially in trade with the Orcoquisac Indians. As early as 1745 Don Jauquin de Orobio de Bazterra had led a party to the region to investigate French intervention among the Indians. During his time as governor of Texas, 1750-1760, Jacinto de Barrios y Jauregui had engaged in illicit trade with the French at Natchitoches. But in 1754 he learned that four Frenchmen, with some Spaniards, had settled in Texas near the mouth of the Trinity River. There Joseph Blancpain, two associates, and two Negro slaves were arrested, and Blancpain revealed that he had expected fifty families to come from New Orleans to found a permanent settlement with a chaplain and a mission for the Indians. In 1755 Barrios had Domingo del Rio visit the

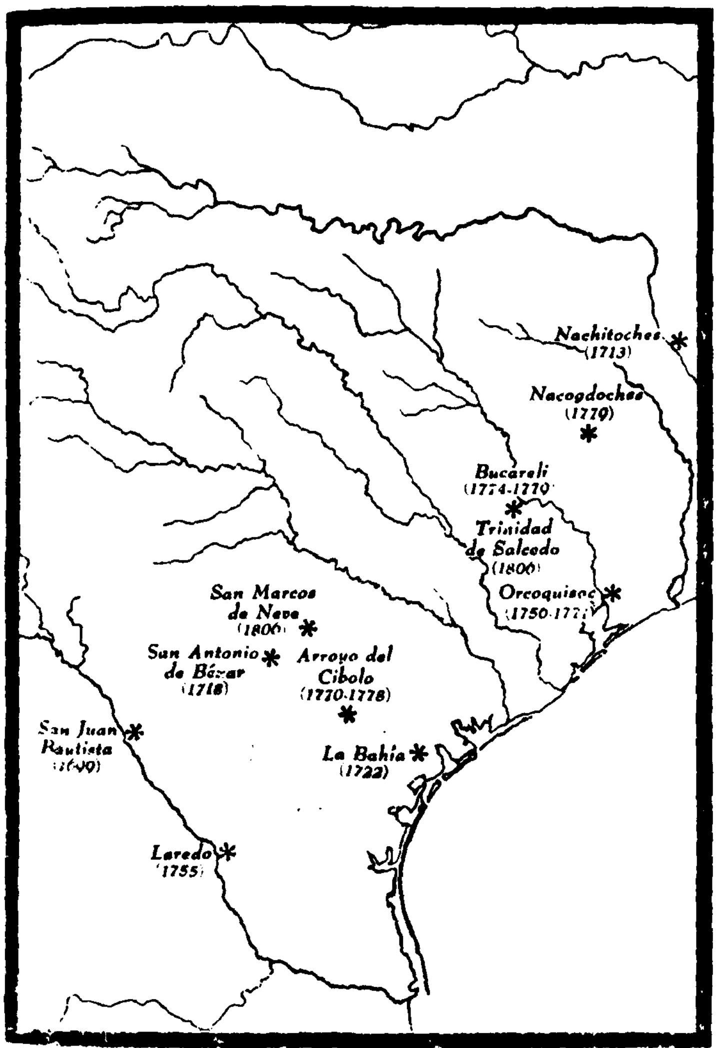
site again, and they learned that a boat had come from New Orleans and had sailed into the mouth of the river, and that other Frenchmen had come on horseback. All of this activity produced a council of war. The Spanish viceroy convened the council of war to determine what to do, and on February 4, 1756 the council declared that a presidio, with thirty soldiers and a mission under the direction of the Franciscan college at Zacatecas, should be established among the Indians on the lower Trinity River. In addition, the council recommended that a subsidized civil settlement of fifty families should be founded at the same place. Governor Jacinto de Barrios y Jauregui set about executing the order. The presidio, San Augustin de Ahumada, was built and Father Romero from Los Ais founded the mission, Nuestra Senora de la Lux del Orcoquisac. The civil settlement, however, was never established. There were two friars in residence, and when the elder died the other requested to be relieved because of the biting insects, extremes of heat and cold, and the thick and stinking water that he had to endure. In 1767 a visitation recommended the mission's abandonment, and in 1771 it was withdrawn to protect the Spanish there from a feared Apache raid. For several years the Indians continued to request in vain for the re-establishment of the mission. Prior to their abandonment of the area, however, the Spanish established the Atascosito Road as a military highway. The road extended eastward from Refugio to the Trinity River, and eventually beyond. A trail led from Nacogdoches to join it near the Orcoquisac mission.

The decade of the 1770's witnessed another Spanish settlement on the Trinity River. In 1773 Governor Ripperda was forced to execute an order from New Spain that all settlements in East Texas were to be withdrawn to San Antonio. In July, 1773, all Spanish settlers in the area started for San Antonio and the last of them reached there by late September. They were very unhappy, and they soon petitioned to be allowed to return. Their spokesman was Antonio Gil Ybarbo. Ripperda could not let them return all the way home, but he agreed that they could remove eastward so long that they did not come within one hundred leagues of the French, providing the viceroy agreed. Ybarbo and Vital Flores also secured the viceroy's permission, and in 1774 they set out for Paso Tomas, the crossing of the Old San Antonio Road on the Trinity River. There they established the settlement known as Nuestra Senora del Pilar de Bucareli. For four years the town did well, but in May, 1778, the Comanches raided it, and in October they returned in even larger numbers. Then in

the spring of 1779 the Trinity River flooded their village and the Comanches returned soon after the waters receded. The settlers determined that the conditions at Bucareli were worse than the wrath of the governor and in April they followed Ybarbo and Flores eastward. They established the community of Nacogdoches in April, and it became the third permanently settled area in Texas.

The Anglo-American impact on the Trinity River region will be discussed in greater detail in the next section, but its influence will be felt early by the Spanish, and a word needs to be said about its beginnings. For some time Anglo-Americans had been entering Spanish Texas illegally. As early as 1800 Charles Boyles was given the right to establish a ferry on the Trinity River by Jose Miguel del Moral, but he shortly lost this franchise when he was discovered illegally permitting smuggling by admitting a boat from New Orleans. The purchase of Louisiana by the United States further complicated the border tenseness, and the activities of the mustanger Philip Nolan in the Trinity River region aroused Spanish fears about an American takeover. Later, the filibustering invasion of Augustus Magee (1812) and Dr. James Long (1819) would confirm their fears. To check this present and anticipated American activity, the commander of Spanish forces in Texas, Nemesio Salcedo, acted swiftly. He ordered troops to occupy the old presidio at the mouth of the Trinity River, and he directed that more settlements be established between San Antonio and Nacogdoches. In 1806 Villa Santisima Trinidad de Salcedo was founded on the western bank of the Trinity River near the crossing of the Old San Antonio Road. The village was established by five families from San Antonio and twenty-three families from Louisiana. A detachment of soldiers was sent to guard them, and the town grew slowly. Later other families were consolidated there, and a census in March, 1809, listed 92 persons in residence. See Appendix A for instructions given to a reconnoitering expedition in this region.

In summary, the European period of immigration spanned many years but produced little impact upon the river or its drainage area. After initial Spanish entradas revealed an absence of precious metals, their interest was negative--they only wanted to keep the land from the French and later the Americans. A few settlements were established over the years, either as missions, military guard posts, or as towns by actual settlers, but by the time that Spain lost its new world



Principal Settlements in Spanish Texas

empire in the 1820's, the Trinity River was substantially as it had been for thousands of years. The coming of the Anglo-Americans would make a considerable change in that.

ANGLO-AMERICANS

The Anglo-American encounter with the Trinity River began prior to the turn of the nineteenth century, but it was after that date that any appreciable number of permanent immigrants came to the region. As early as 1799 Philip Nolan had established a pasturage ground on the Trinity River for his mustangs, and no doubt early trappers had found the stream already. In 1807 Zebulon M. Pike discovered runaway Negro slaves at the place where he crossed the river in the Forks region. By that time the trading firm of Barr and Davenport had established an extensive cattle ranch just below the Robbins' Ferry crossing, although the ferry was not established until 1821 by Nathaniel Robbins. This was at the crossing of the San Antonio Road, and to the north there were a few clusters of settlers who occupied several Spanish grants. It was good country, but it was remote from the sea and somewhat exposed to Comanche raids. When the impresarial developments started, the Trinity River valley country attracted many settlers because of its agricultural potential and the hope that the river would provide an easy and inexpensive route over which to ship their produce.

Settlers or visitors who came to the Trinity River region in the early days came either by sea or over land. If by sea, they saw, as did George Graham who came in 1818, the broad Galveston Bay (he called it the Trinity Bay) with its several river openings, but he also noted that each was partially blocked by a bar which often would afford less than four feet of water. If by land, they tended to gravitate to one of the early established crossings, the Upper, located at Magnolia and called the oldest road in Texas; the Middle, at Robbins' Ferry, where de Leon had crossed the river in 1689; and at the Lower, at Liberty, established in 1805. In either case settlers had already begun to filter in long before Spain legally made their lands available to Anglo-Americans. In fact, some of the early Anglo-Americans came primarily to wrest control of the Texas region from them. Nolan is regarded as the first of the Americans who came for such purposes, and he was followed in 1812 by the forces of Augustus Magee and his Spanish partner, Bernardo

Gutierrez de Lara. They proclaimed the Republic of the North and stationed men along the Trinity River. Magee was unsuccessful in his attempt, however. In 1819, after the Adams-Onis Treaty had renounced American claims to the lands west of the Sabine River, several Americans who were dissatisfied with this solution followed Dr. James Long into Texas as far as the Trinity River and on down to Galveston, again in an unsuccessful attempt to establish a personal empire in Spanish lands. Then in the 1820's Stephen F. Austin and others received permission to settle portions of Texas on impresarial grants. The Trinity River had several such grants along its banks, including Cameron's Grant, in the headwaters, then passing through Filisola's Grant, the western half of David G. Burnet's Grant, and finally Joseph Vehlein's Grant on its western edge before emptying into Galveston Bay.

Among the early American visitors to the Trinity River was Frederick Law Olmstead, one of the famous early nineteenth century traveler-observers. Olmstead was touring Texas and reporting on his adventures for the land-hungry American audience. His descriptions are valuable both for what he saw and for what his writings produced in America. He approached the Trinity River by land and had an eventful and perilous crossing at a ferry. He observed that the Trinity River was considered the "best navigable stream of Texas," but noted that there had been no rise in the winter and that no rise meant no navigation for six months. At high water he was told that it was navigable all the way to the Forks region, but this is questionable. Travelling the river, he reported that the lower regions were filled with canebreaks and thick undergrowth, especially vines, among the hardwood trees. Farther up-river, however, this gave way to a prairie that was well suited to grazing, and in the headwaters region the country was fine for planting cotton, wheat, and corn.

By the time of the Texas Revolution, the thrust of Anglo-American settlement had passed far beyond the Trinity River. It was to play only one significant role in the developments of the revolution, however. After the original military reverses at the Alamo and at Goliad in March, 1836, many of the Americans, especially the non-combatant population who considered themselves vulnerable to General Santa Anna's armies, fled before them in a wild melee known as the Runaway Scrape. Eventually fleeing all the way to Louisiana, many were temporarily halted by the Trinity River's swollen flood-tide. The

spring showers and washed away the ferry boat and they were forced to cross under the most difficult of circumstances after discarding most of their belongings on the banks of the river.

After the Texas Revolution, immigration increased. Already established towns such as Anahuac and Liberty, which antidated the Revolution, were soon joined by such new settlements as Cincinnati, Trinidad, Carolina, (formerly Bath), Geneva, Swartwout, Rome, Pompei, Franklin and Magnolia. The advent of steamboats would bring into being many more river landings and river towns; and people living on the river needed public services. In May, 1838, the Congress of the Republic established a mail route from Houston to San Augustine, which crossed the Trinity River at Captain Hirams' place. The mails were brought from Fort Jesup in Louisiana to the Trinity River via Nacogdoches by a Jesse Walling, who apparently carried it to Robbins' Ferry. Later a route was also established from Nacogdoches to Cincinnati, and eventually to other population concentrations along the river.

In the early 1840's the development of the upper Trinity River began. In the previous decade Warren A. Ferris and John H. Reagan did extensive surveying work in the region. In 1840 Jonathan Bird established a fort on the military road that ran from the Red River to Austin near where the road crossed the Trinity River, and it was there in 1843 that Sam Houston negotiated an important peace treaty with the Indians. In 1840 John Neely Bryan selected the location where the West Fork and Elm Fork of the river from the main trunk of the Trinity as the site of a ferry, and it eventually became the sprawling city of Dallas. At first its growth was slow, but the river and especially later rail connections gave it advantages over other inland communities. To the west, on a bluff overlooking the river, Fort Worth was established in 1849. In the 1850's Victor Prosper Considerant established a socialist colony on the south bank of the Trinity River on what is generally termed the "old Fort Worth-Dallas Pike." Based on the teachings of Charles Francois Fourier and Considerant, it was named La Reunion and was legally established on September 1, 1856, but it was not successful.

The most important aspect of Anglo-American utilization of the Trinity River in the nineteenth century deals with its steamboat activity. Long considered a prime prospect for such utilization, it was regularly

open only as far as Liberty and/or some distance above, but gradual efforts were put forth to make it navigable all the way to the Forks region. Serious traffic on the Trinity began as early as 1836. In that year Mrs. Mary Austin Holley said that the river was navigable for about two hundred miles. In 1838 the *Branch T. Archer* ascended the river to Cincinnati, taking advantage of a series of rains in May that had swollen the stream. The captain agreed to establish a regular run between Galveston and Cincinnati, when possible, and the proprietor of that city, James C. Dewitt, agreed to provide sufficient business and donate some town lots. In the next year other vessels, the *Pioneer*, the *Corerreo*, the *Friend*, the *Trinity*, and others made the voyage to Cincinnati. In the early 1840's the *Ellen Frankland* and the *Vesta* joined in plying the river, the latter going as far as Magnolia, the landing place that serviced Fort Houston, and later a thriving town in its own right. In 1843 the English observer William Bollaert descended the Trinity River aboard the *Ellen Frankland*. His description, published in *William Bollaert's Texas*, edited by W. Eugene Hollon and Ruth Lapham Butler, is one of the finest descriptions available of steamboating on the Trinity River.

By spring, 1843, some smaller vessels were making it all the way to the Forks region, near the soon-to-be established community of Dallas, although regular sailing that far inland was not regularly established. In 1868 Captain James Garvey tied up his sixty-foot sternwheeler in Dallas, the first steamer to ascend the river that far. He had taken one year and four days for the trip, with time out for removing logs and snags. See Appendix B for a list of landings and boat facilities on the Trinity River in this century, with the distance of each from Galveston.

George Bonnell, in his *Topographical Description of Texas*, has provided a fine description of the Trinity River during these times:

> The Trinity River is the largest tributary of Galveston Bay. By the meanderings of the river it is more than six hundred miles in length, and has been navigated by steam boats two hundred and fifty miles, and it will be navigated in all probability, much farther. For eighty miles above its mouth, it runs through a low prairie country, but has wide and heavily timbered bottoms.

Old river, which enters the Trinity three miles from its mouth, from the west, is thirty-five miles in length. It is a broad, deep channel, and navigable nearly to its source for steam boats. It is believed to have once formed the bed of the Trinity River. It runs through a low marshy country, with heavily timbered bottoms. The land is rich and well adapted to the cultivation of sugar, cotton, or corn, and affords an unbounded range for cattle.

Sixty miles from the bay, on the east side of the river, stands the town of Liberty. It is the seat of justice of Liberty County, and has about one hundred inhabitants. It is surrounded by a rich and pleasant country. The country between this town and the mouth of the river, and for thirty miles above, is generally low prairie--with occasional spots of timber. The land is generally rich--the bottoms wide and well timbered. Franklin is a small town upon the east bank of the Trinity River, about thirty-five miles above Liberty. It is a place of very little importance.

Cooshatta, or Kettle Creek, enters the Trinity River eighty miles above Liberty, from the east side. This creek is about thirty-five miles in length; has its source in the pine woods, and affords no good land except the bottoms, which are not extensive. From the mouth of this creek to the old San Antonio road, on the east side of the river, the country presents nothing but a long leaf pine barren, which extends nearly to the Neches River. The bottoms, however, are generally wide and rich, presenting a dense undergrowth of cane. The Cooshatta Indians now reside in this section of the country.

Milton and Kickapoo creeks are two small streams, which enter the river from the east, in this section of the country. They differ in soil but little from Cooshatta creek.

Between the mouths of these two creeks, on the east bank of the Trinity River, is the new town of Swartwout. It is situated in a healthy and beautiful country, upon a high bluff, and contains many advantages as a commercial point. It is rapidly improving.

Geneva, situated on the west bank of the river, is a new town, just laid out, which will be a candidate for a portion of the commerce of the rich valley of the Trinity.

On the west side of the river, the country differs materially from that on the east. Immediately above Liberty on the west side commences a beautiful rolling country, agreeably interspersed with woodland and prairie, which extends to the San Jacinto River. Oak, Cooshatta, and Bidias creeks are three small streams which enter the Trinity from the west. They all afford an abundance of good land and plenty of timber. The timber is mostly pine, oak, hickory, black jack, and some other kinds. This country affords fine springs and plenty of running streams. It is generally a good body of land, and well watered.

At the mouth of Bidias creek stands the town of Carolina, on the west bank of the Trinity River. It is a new place, or rather has a new name. It is pleasantly situated and has a great variety of mineral water, white and red sulphur, calibeate, etc. From this circumstance, it had received the name of Bath, and had been known on the maps by that designation for many years; but was, in very bad taste, changed by the Proprietors to Carolina. I dislike to see a sacrilegious hand land upon ancient names.

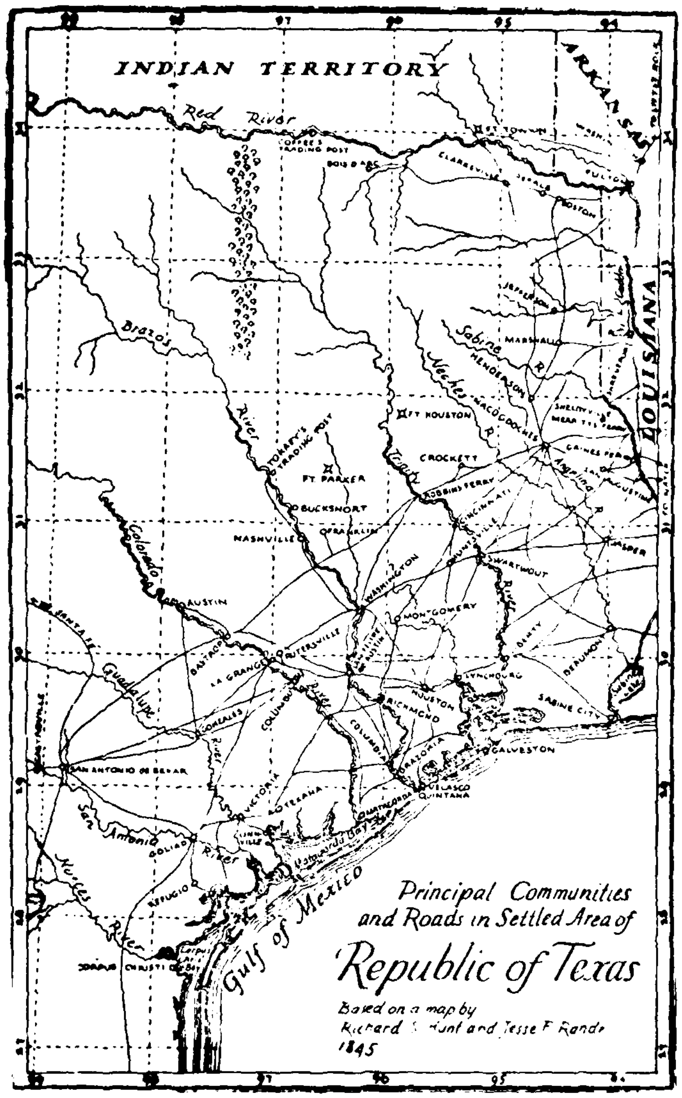
Bear creek is another small stream which empties into the Trinity from the west eight miles above Carolina. The land upon the creek, and between it and the old San Antonio crossing, differs but little from the last described.

At the crossing of the old San Antonio road, on the west side, is the town of Cincinnati. It is a flourishing little village, and surrounded by a fine body of excellent land. Steam boats have frequently ascended to this point, but it is not believed to be the head of navigation.

Above this road the lands on both sides of the Trinity are rich, well timbered, and well watered to its source. This river flows through the country lately occupied by the Cherokees and their associate bands which has heretofore prevented its settlement. But now they have been driven out,

> the natural wealth and advantages of that country must command a speedy settlement, if not prevented by legislative enactments. It is nearly all a heavy timbered country, with but an occasional small prairie. The timber is white and red oak, black jack, hickory, Bois d'Arc, and occasionally short leaf pine. The country abounds in fine springs and running streams of fresh water. Several fine salt springs have been discovered, from which the Indians have been in the habit of manufacturing considerable quantities of salt.
>
> A good quality of stone coat is found in several places, within steam boat navigation on the Trinity, and might be floated down in any quality.
>
> Hurricane and Bois d'Arc creeks are the principal tributaries from the east; and Rich Land creek and the West Fork from the west. The land upon all these streams, differs but little from that on the Trinity River.
>
> Crockett is a flourishing inland village on the headwaters of Hurricane creek. It is the seat of justice of Houston county, and contains about one hundred and fifty inhabitants.
>
> Eighty miles above Cincinnati the prairie again commences. It is rich, rolling, and beautifully interspersed with groves of timber; this kind of country extends to the Cross Timbers.

The steamboat era declined after the coming of rail competition but the promoters of Dallas have never given up on the idea of an outlet to the sea. In 1890 several Dallas businessmen organized the Trinity Navigation Company to open "the Trinity navigation again" to reduce rail rates. They launched a sixty-four foot vessel, the Dallas, but their efforts to reopen the river's commercial navigation lasted only about twenty years. In 1893 a lock and dam was constructed near Highway 21 to ease passage through the area. The U. S. Congress, in the meantime, had authorized the building of several locks and dams along the river, and in 1914 a similar improvement was made. World War I halted the development, and after the war such projects were allowed to lapse. In 1936 Amon G. Carter and John W. Carpenter inspired the Trinity River Association, which sponsored the establishment of the Trinity Watershed Soil Conservation and Flood Control Association. This was merged with



Principal Communities and Roads in Settled Area of

Republic of Texas

Based on a map by
Richard S. Hunt and Jesse F. Randel
1845

the Trinity River Canal Association to form the new Trinity Improvement Association. Then in 1939 the U. S. Corps of Engineers recommended flood control projects, including dams. In 1945, Congress authorized some of this work. See Appendix C for a summary of the work, circa 1945. In 1955 the Trinity River Authority was created, and it continues until today in efforts to sponsor the development of the Trinity River to navigation and other uses, such as flood control, surface water for urban consumption, and recreation.

In summary, the Anglo-American impact on the Trinity River had eclipsed all other human uses. From a settlement area to a major development project, the impact of man has been considerable in the last two centuries. If further developments, such as channelization, are pursued, the river's appearance will change much more rapidly in the future than it has in the past.

COUNTY SURVEY

The following section is a county by county survey of historic sites on the Trinity River. The locations were assembled from various sources, as described in the Introduction, but the most valuable single source is the Texas State Historical Survey Committee, especially Ms. Patricia S. Morrison, Research Assistant, and the various County Historical Survey Committee Chairmen for the counties which lie along the course of the river. The following list will provide names, addresses, and telephone numbers for these people. In some cases they will be happy to answer inquiries directly; in any case they are the best starting point in any of these local jurisdictions.

County Historical Survey Committee Chairmen Along the Trinity River

Mr. Guy C. Jackson III
Chambers County Historical Survey Committee
P. O. Box 308
Anahuac, 77514
713/ 267-3141

Mrs. Edward Pickett
Liberty County Historical Survey Committee
2305 Webster
Liberty, 77575
713/ 336-5397

Mrs. John J. Hollenburger
Polk County Historical Survey Committee
P. O. Box 15
Livingston, 77351
713/ 327-4552

Mrs. G. F. Hollis
San Jacinto County Historical Survey Committee
Coldspring, 77331
713/ 653-4284

Mrs. Vernon Schuder
Walker County Historical Survey Committee
P. O. Box 14
Riverside, 77367
No Telephone Listed

Mrs. Frances Mangum
Trinity County Historical Survey Committee
P. O. Box 469
Trinity, 75862
No Telephone Listed

Madison County Historical Survey
No County Chairman
County Judge: The Hon. J. C. Wells
Madisonville, 77864
No Telephone Listed

Miss Eliza Bishop
Houston County Historical Survey Committee
629 North Fourth Street
Crockett, 75835
713/ 544-3269

Mrs. Lorene Dickey
Leon County Historical Survey Committee
P. O. Box 97
Centerville, 75833
214/ 536-2927

Mrs. Sam Ballard
Anderson County Historical Survey Committee
Neches, 75779
214/ 584-3285

Mr. Uel L. Davis, Jr.
Freestone County Historical Survey Committee
P. O. Box 26
Wortham, 76693
817/ 765-3482

Mr. Arthur Patrick
Navarro County Historical Survey Committee
Corsicana National Bank
Corsicana, 75110
214/ 874-7472

Mr. Theo Daniel, III
Henderson County Historical Survey Committee
P. O. Box 670
Athens, 75751
214/ 675-3055

Mr. Jack Anderson
Ellis County Historical Survey Committee
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Midlothian, 76065
214/ 775-3887

Mrs. James A. Miller
Kaufman County Historical Survey Committee
313 Elm Drive
Terrell, 75160
214/ 563-2372

Mr. John Plath Green
Dallas County Historical Survey Committee
2191 1st National Bank Building
Dallas, 75202
214/ 742-3874

Dr. John E. Perkins
Tarrant County Historical Survey Committee
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Arlington, 76010
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In the seventeen counties covered by this report, the following historical sites have been located on or near the Trinity River and are noted for possible impact by development:

Chambers County

Anahuac. Founded in the 1820's near the mouth of the river.

Wallisville. Near the present dam construction site, Wallisville is another 19th century community. On Interstate Highway 10 near the Trinity River bridge.

Orcoquisac Indian Village, and the Spanish mission and presidio site. On Interstate Highway 10 near the Trinity River bridge.

Liberty County

Atascosito Road Crossing. Crossed the Trinity River about three miles north of Liberty.

Old Spanish Trail. Crossed the Trinity River at Liberty. A ferry operated here until 1913.

Day's Landing. Located south of Liberty, on Elizabeth Musson League.

Cole's Landing. Located south of Liberty, on South League.

Taylor's Landing. Located south of Liberty, on South League.

Snell's Landing. Located north of Liberty, on James Hanney tract.

Wreck of steamboat, Mary Conley, off William Swail's tract.

Wreck of steamboat Black Cloud off Reason Green's tract.

Polk County

Smithfield. Established by 1834 on the Trinity River. Later, it was moved a mile up the river, became a port, and by 1841 had a post office named Smithfield. The story is that Smith farmed for an influential citizen, and the tract he cultivated was called "Smith's Field". The name was changed to Ace in 1915 when Asa Emanuel became postmaster.

Drew's Landing. A trinity River port founded by 1840 in 1843 Monroe Drew and Joseph Baird bought a sawmill under construction, a ferry and a dwelling. Later Drew bought out Baird, and the name Drew's Landing was never in doubt. In 1965 it was a large subdivision with lakes, attracting many retired couples who built their homes there.

Swartwout. A Trinity River port and ferry. Was laid out for a town in 1838 by James Morgan, Arthur Garner and Thomas Bradley. It was named for Samuel Swartwout, New York Financier, a friend of James Morgan. A post office by 1843, reestablished May 1846. Continued until 1872 when railroads took the trade from steamboats.

Johnson's Bluff. A ferry and port known to have existed by 1846 and probably before 1840. Built by John R. Johnson a surveyor. By 1858 was large enough to be listed as a town on County Tax Records. Most of the town was on the side of the Trinity that became San Jacinto County in 1870.

Patrick's Ferry. A river port and ferry at the mouth of Kickapoo Creek, established by Isham T. Patrick in 1844. Operated until the 1870's.

San Jacinto County

[Contiguous to Polk County, there will be some overlap of information.]

Bath. Later known as Carolina. In northernmost part of county. Laid out before 1840. At point where Carolina Creek flows into Trinity River. Only a few heaps of stone remain.

Battise's Indian Village. Located near Patricks's Ferry.

Patrick's Ferry. A trading point near the mouth of Kickapoo Creek where the old road from Lynchburg crossed the Trinity. Flooded by Lake Livingston.

George Tyler Wood's home. Located near the river on Ben Ash Hill.

Swarthwout. Although the main community was in Polk County, some dwellings were located on the San Jacinto side.

Washington plantation. Site of Captain William W. Hunter's inland headquarters, 1862, located on the Logan League. Naval equipment and supplies were stored there.

San Jacinto County sites inundated by Lake Livingston: Jones' Bluff, Harrell's Landing, Johnson's Bluff, and Grace's Landing.

Walker County

Newport. Founded circa 1854 by Joseph Werner, a German storekeeper. Perished in 1871 when the railroads arrived.

Cincinnati. Founded circa 1837 by James Dewitt who surveyed the townsite. In 1846 was the county seat of Walker County.

Ferrages on the river above Cincinnati: Wyser's, Easthom's, and Calhoun's.

Madison County

Bucareli. Founded in 1772. Located near river crossing of Old San Antonio Road.

Leon County

Kickapoo Shoals Landing.

Henderson County

De Leon's Crossing at mouth of Boggy Creek.

Brookfield Bluff Landing.

Kickapoo Village.

Hall's Bluff Landing.

Anderson County

Magnolia. Founded in 1840's as a ferry on the Trinity at Caddo Trace, became a major landing for flatboats and steamboats. Named for a huge tree in the center of the community.

Parker Bluff.

West Point.

Troy.

Houston County

Robbin's Ferry. Crossing of Highway 21.

Alabama, and Alabama Crossing.

Clapp's Ferry.

Hurricane Shoals and Dam. Near crossing of Highway 7.

Hightower Ferry

Ellis County

Trinidad Ferry.

Slaterock Ferry.

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Maps: (1) principal escarpments and belts in Texas Gulf Coastal Plain; (2) three natural regions of Texas through which the lower Trinity passes; (3) natural regions of the lower Trinity; (4) vegetation in the lower Trinity; (5) Indian tribes of the Gulf Coast; (6) Texas in the 18th century; (7) Stephen F. Austin's map of lower Trinity region; (8) lower Trinity and Lake Charlotte below Liberty; (9) Austin's map of region in 1822.
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Tables: Henderson County Levee Improvement District No. 3; Erosion Chart of Trinity River Diversion Channel; Myers, Noyes, and Forrest, Engineers.
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APPENDIX A

[Bexar Archives--University of Texas Archives, Austin] *Governor J. B. Elguezabal to Pedro Nolasco Carrasco, September 17, 1805.*

Instructions to be Followed by Captain Don Pedro Nolasco Carrasco in Command of a Reconnoitering Expedition that is to be Stationed on the Banks of the Trinity River:

1. For the present your forces will consist of one hundred and twenty men from the Province of Coahuila, together with three especially trained soldiers of the Company of Bexar. These you will station in the most convenient place, on whichever side of the river you find safest and most comfortable for the troops and where the pasturage for the horses you carry with you is to be found.

2. You will set out from here with one hundred and sixty men from Coahuila and fifteen from Punta de Lampazos. Forty of the first mentioned, including Ensign Don Jose Maria Gonzales, will follow your march to Nacogdoches, under orders of the Captain Don Sebastian Rodriguez. The fifteen from Punta de Lampazos will be under the command of Sergeant of Bavia, Jose Andres Cadena. They are to be guided by a scout from the Company of Bexar, and should proceed immediately to the detachment at Orcoquisac, now located at Atascosito. There will then be left in the camp under your charge said one hundred and twenty men and the three scouts from the Company of Bexar, who have been ordered out on special duty.

3. After selecting a site large enough for the force of men you carry with you, and dedicated even for a larger force that may be added to this, you will build barracks to protect the supplies and the lives of the soldiers. With the barracks you will form a square and will place guards at the most advantageous positions for giving the best possible protection.

4. You shall make one, two or more trips over the pastures to round up the horses on dark nights in order to avoid losing them in stampedes, and prevent losses by

their joining the wild horses that are there in large numbers.

5. Since the Detachment of Nacogdoches must keep their horses close to the camp under your care, you will send to that place the horses that the Commandant requests for the service and receive those that he sends you back.

6. Your chief duty will be to furnish the recruits that might be requested of you by the Commandant of the said Post of Nacogdoches and the Commandant of Orcoquisac. You are likewise to maintain the most amicable and harmonious relations with the tribes living on the banks of the Trinity and the Brazos Rivers as well as the regions around said post. Make them understand in the clearest possible manner that our faithful friends have nothing to fear through the large increase of Spanish troops; that far from containing the least threat, this plan is to ratify and confirm our friendly treaty, to take them under our protection, to care for their interests in case any other country than Spain tries to oppress them or cause trouble in their country, which Spain has protected and watched over since time immemorial. With such an idea in mind, the head and subordinate chiefs who influence the individuals of the tribe not to cause any harm or commit any thefts so as not to place us under the necessity of punishing them. If this should be necessary, however, it should not disturb our amicable relations in any way.

7. These conversations (talks) which you should frequently hold with such chiefs as you meet with will secure peace and the respect of the tribes. By this means you can acquire much information which will be of value to you. You can thus provide yourself with faithful guides and with warriors to reinforce our troops when necessary.

8. The captain to whom these instructions are addressed shall carry with him from here a skilled workman to build a raft and two canoes on the river on which you will encamp. He is to receive here an advance of forty pesos. On the day that he delivers the work there he should be paid one hundred pesos--these being his total pay. He should press this work and when he has finished it he should deliver the ferry-boat and one of the canoes to the camp on the Trinity to be used there. The other should be sent down the river by trained men, and with the necessary guard, to deliver it to the Commandant of the Detachment of Orcoquisac, located at Atascosito.

9. Since certain men and their families are going out with these troops, carrying foodstuffs and certain other supplies for the purpose of setting up shops, I have permitted them to locate in the camp, so that they may become one of the founders of one of the settlements in the future. I am recommending to the superior government that they and their property should be under the protection of the camp. However, they should be kept under surveillance by the Commandant so that they may not, under this pretext, try to drive out stock illegally and thus become involved in contraband trade. This must not be construed as reflecting on the manner of the said individuals, nor upon the upright purposes they claim to have, that of settling this section, for it is very important.

10. With the knowledge that the introduction of goods from Louisiana into this country and the driving out of stock to that province, and to the United States of America is an illegal traffic which is prohibited by His Majesty, the Commandant will arrange to have all offenders arrested and their goods or horses seized. They shall be sent to this capital with a letter which will serve as the occasion for legal procedures.

11. Strict discipline of the troops is the basis for victory in war, and for quiet and order during peace. No precautions nor any formal procedure in the service shall be omitted, since this will contribute to the safety and defense. The troops shall frequently engage in exercises and tactical movements, both on foot and on horseback, so that when they are called into action they may be worthy of the name of Spaniards and on every occasion prove the valor that has always been ascribed to them.

12. When circumstances demand it, he shall take care to increase the observation groups so that every time they can be furnished whatever help may be needed, always leaving a sufficient force for the protection of the camp. This point should not be neglected nor the purpose abandoned. This will make it possible to send messengers as well as to transport provisions and other supplies. It may likewise be noted that during the heavy rises in the river during the winter season, it will be wise to maintain the camp and keep the horses on the other side of the river, for I understand that the ferryboat will not be sufficient to ferry over the stock in such emergencies.

Bexar, September 17, 1805 (Draft.)

APPENDIX B

Boat Landings on the Trinity River, Nineteenth Century

Name of Landing	Distance from Galveston in Miles
Mouth of Trinity River	55
Wallisville	60
McManus Landing	68
Moss Bluff	83
Moors Bluff	90
J. Garner's	102
Liberty	103
Rodger's	104
Green's Ferry	109
Green's Mill	110
Hardin's	127
Robinson's Bluff	147
Tanner's	149
General J. Davis Landing	157
Farrior's	165
Field's	168
Long's	182
Nevill's	183
Ellis & Cherry	184
Cut Off	192
Smithfield	200
Washington's (West Side)	201

Drew's Landing (East Side)	204
Summer's	207
McCardell's or Willow Bluff (East Side)	208
R. Smith's	210
Cedar Landing	215
Victory (East Side)	219
Swartwout (East Side)	221
Pinkney's Bluff	227
Green's Landing	242
Johnson's Bluff (West Side)	244
Harrell's Landing (West Side)	252
O. Wheler's Landing	258
Wood's Landing	261
Patrick's Ferry	262
Foster's Yard	267
Fry's & Lumpkin's Landing	270
West Lumpkin Lodge	271
Ryan's or Bern's Ferry	272
Sol Adam's Landing	274
Sebastopol	276
White Rock	278
Carolina	282
F. B. Sublett's	283
McDonald's Landing	284
Thomas's Landing	285
Newport	286

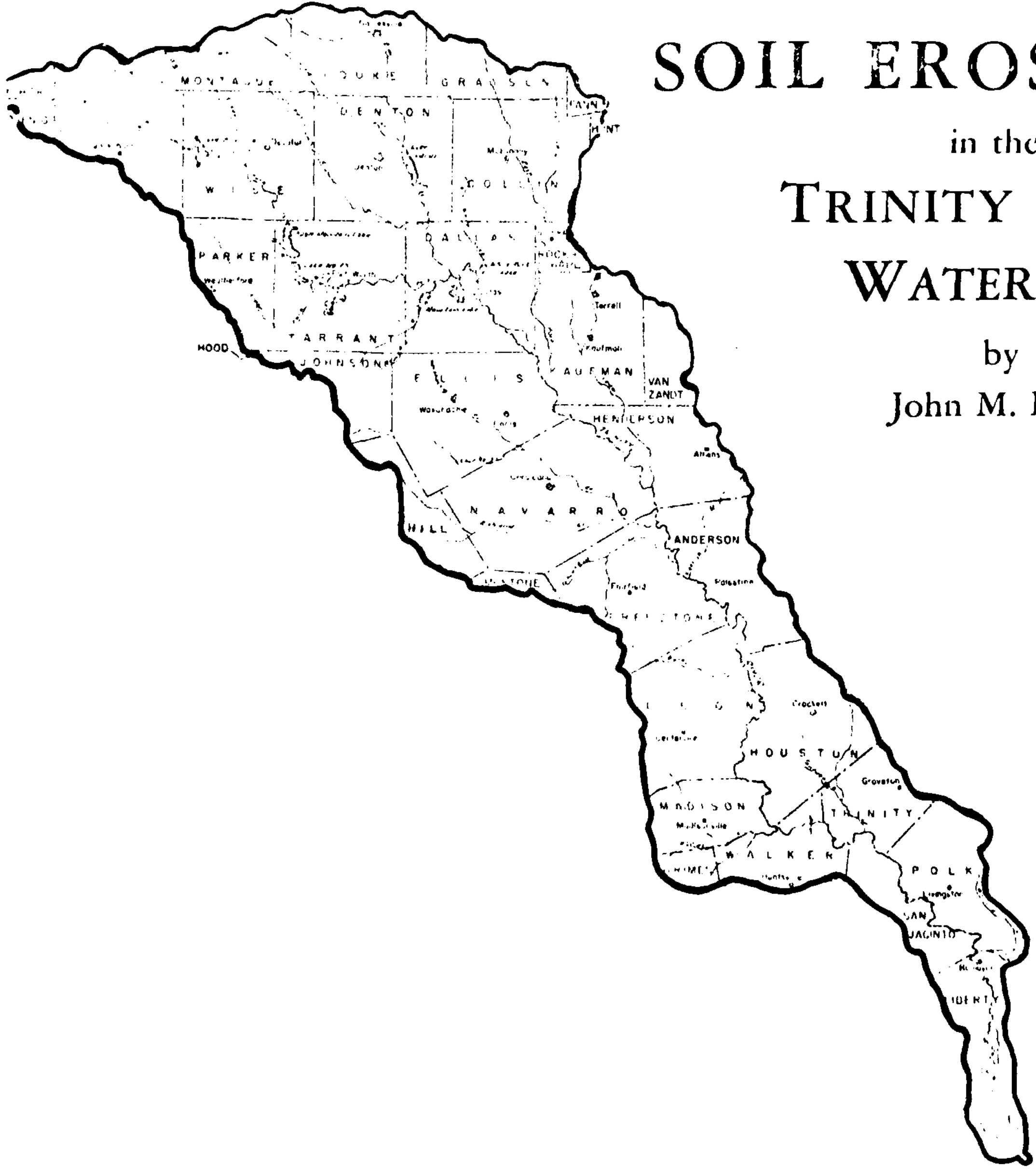
Stubblefield	289
D. Ferris Bluff	293
Harrison's Bluff	294
Mrs. McKinley's Landing	298
Alfred's Bluff	302
J. C. Dunlap's	304
Whites Old Ferry	311
Cincinnati	313
Tuscaloosa or Weiser's	315
Goree's Landing	320
Osceola or Calhoun	321
Mrs. Wright's	325
Spanish Bluff	335
Westmoreland	336
Clark's Bluff	339
Clapp's Ferry	347
Bogman's Landing	353
Cairo	362
Warren's Landing	372
Alabama	377
Robins Bluff	380
Adair's Landing	382
Brookfield Bluff	388
J. Still Landing	389
Beaver's Landing	395
Kickapoo	396

Hall's Bluff	398
Barkley's or Hogpen Bluff	400
Dangerfield's	406
J. Smith's Landing	410
Navarro	418
Bannerman's	425
Magnolia (Near Palestine)	440
Blacksher's	448
Bonner's Ferry	458
Parker's Bluff	461
Haygood's Ferry	467
West Point	469
Evan's Landing	481
Pine Bluff Ferry	496
Green's Bluff	512
Ingrum's Bluff	521

The Program for FLOOD CONTROL AND THE PREVENTION OF SOIL EROSION in the TRINITY RIVER WATERSHED

by

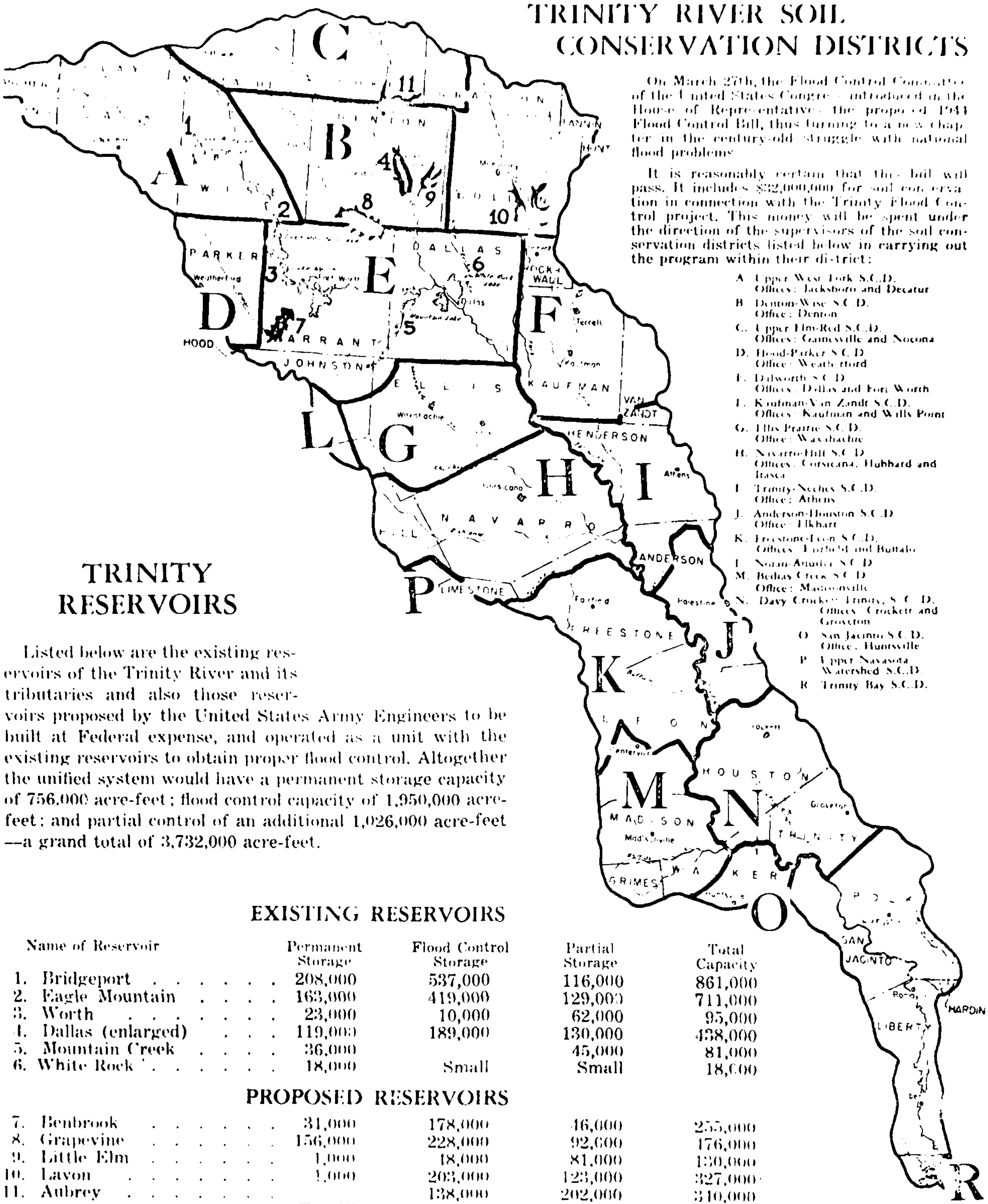
John M. Fouts



TRINITY RIVER SOIL CONSERVATION DISTRICTS

On March 27th, the Flood Control Committee of the United States Congress introduced in the House of Representatives the proposed 1944 Flood Control Bill, thus turning to a new chapter in the century-old struggle with national flood problems.

It is reasonably certain that this bill will pass. It includes $32,000,000 for soil conservation in connection with the Trinity Flood Control project. This money will be spent under the direction of the supervisors of the soil conservation districts listed below in carrying out the program within their district:



A. Upper West Fork S.C.D.
Offices: Jacksboro and Decatur

B. Denton-Wise S.C.D.
Office: Denton

C. Upper Elm-Red S.C.D.
Offices: Gainesville and Nocona

D. Hood-Parker S.C.D.
Office: Weatherford

E. Dalworth S.C.D.
Offices: Dallas and Fort Worth

F. Kaufman-Van Zandt S.C.D.
Offices: Kaufman and Wills Point

G. Ellis Prairie S.C.D.
Office: Waxahachie

H. Navarro-Hill S.C.D.
Offices: Corsicana, Hubbard and Itasca

I. Trinity-Neches S.C.D.
Office: Athens

J. Anderson-Houston S.C.D.
Office: Elkhart

K. Freestone-Leon S.C.D.
Offices: Fairfield and Buffalo

L. Nolan-Aquilla S.C.D.

M. Bedias Creek S.C.D.
Office: Madisonville

N. Davy Crockett-Trinity S.C.D.
Offices: Crockett and Groveton

O. San Jacinto S.C.D.
Office: Huntsville

P. Upper Navasota Watershed S.C.D.

R. Trinity Bay S.C.D.

TRINITY RESERVOIRS

Listed below are the existing reservoirs of the Trinity River and its tributaries and also those reservoirs proposed by the United States Army Engineers to be built at Federal expense, and operated as a unit with the existing reservoirs to obtain proper flood control. Altogether the unified system would have a permanent storage capacity of 756,000 acre-feet; flood control capacity of 1,950,000 acre-feet; and partial control of an additional 1,026,000 acre-feet —a grand total of 3,732,000 acre-feet.

EXISTING RESERVOIRS

Name of Reservoir	Permanent Storage	Flood Control Storage	Partial Storage	Total Capacity
1. Bridgeport	208,000	537,000	116,000	861,000
2. Eagle Mountain	163,000	419,000	129,000	711,000
3. Worth	23,000	10,000	62,000	95,000
4. Dallas (enlarged)	119,000	189,000	130,000	438,000
5. Mountain Creek	36,000		45,000	81,000
6. White Rock	18,000	Small	Small	18,000

PROPOSED RESERVOIRS

Name of Reservoir	Permanent Storage	Flood Control Storage	Partial Storage	Total Capacity
7. Benbrook	31,000	178,000	46,000	255,000
8. Grapevine	156,000	228,000	92,000	176,000
9. Little Elm	1,000	18,000	81,000	130,000
10. Lavon	1,000	203,000	123,000	327,000
11. Aubrey		138,000	202,000	340,000
	756,000	1,950,000	1,026,000	3,732,000

TRINITY WATERSHED FLOOD CONTROL AND SOIL-WATER-FOREST CONSERVATION WILL BE CARRIED OUT DURING A FIFTEEN-YEAR PERIOD BY THREE AGENCIES AT ESTIMATED COSTS AND BENEFITS AS FOLLOWS:

1. Federal agencies: War Department; mainly reservoir construction	$18,500,000	
Agriculture Department; furnishing equipment, labor and technical aid	32,000,000	
Estimated total Federal aid		$50,500,000
2. State of Texas agencies: All State agricultural and conservation agencies co-operating through some 20 Trinity soil conservation districts; county and city governments; levee, water and irrigation districts; estimated		1,000,000
3. Trinity farmers, ranchers and timbermen will install the program with their own labor, teams, equipment and materials found on their own lands	13,800,000	
Maintenance, et cetera, during first 15 years	13,100,000	
Estimated total (practically no cash expenditures involved)		26,900,000
Estimated total costs to all interests		$78,400,000
Minimum average annual benefits (a monetary value cannot be placed on many benefits)		$17,217,000

APPENDIX D

The following markers provide more complete information for the historical sites on the Trinity River discussed in the foregoing sections. Information was obtained from the State Historical Survey Committee.

1. 27" x 42" Official Texas Historical Marker (SMF) Liberty County - 2-4-70 - on Trinity River, U. S. 90, Liberty.

The Trinity River

Longest river lying entirely within Texas. The watershed of the Trinity covers 17,969 square miles, an area larger than any one of the nine smallest states of the union. More than 20 percent of the people in Texas reside in this area--more people than any one of the 24 least populous states.

The first recorded exclusive navigation rights to the Trinity were given by Mexico in 1833 to District Commissioner J. Francisco Madero, but before he could exercise his rights, the Texas Revolution intervened.

As early as 1838, during the Republic of Texas, steamboat navigation had begun on the Trinity. The famous steamer "Ellen Frankland" plied it regularly. In 1852 a survey authorized by the U. S. Congress reported that "The Trinity River is the deepest and least obstructed river in Texas." The river played a vital role in the Civil War, when a company of Alabama-Coushatta Indians transported key military supplies and boats from Anderson County to waiting Confederate officials in Liberty. Until 1874 steamers chugged from Galveston to as far north as Porter's Bluff in Ellis County. Under the River and Harbor Act of 1965, Congress authorized the comprehensive development of the Trinity Basin's water resources.

2. Atascosito

A Spanish settlement on the Atascosito road was established here in 1757 to prevent French trade with the Indians. Four and one-half miles west of here the road crossed the Trinity. There Alonso de Leon, Spanish explorer, crossed in 1690. The road from Goliad to Opelousas, Louisiana, known as the Lower Road, extensively travelled from 1750 to 1850, also crossed there.

3. 16" x 12" Official Texas Historical Medallion Plate Liberty County - 2-20-68 - on building 9 miles SE of Cleveland on Highway 321.

Old Wells' Store

Center section built about 1875 by D. W. Proctor & Company; later operated by L. L. Wells.

This structure and earlier one on same site each served as general mercantile store. This building was center for visits and exchange of local news at "Tarkington's Prairie" community. Building has been used as post office, wagon stop, credit house, and voting place. Was located on Old Nacogdoches-Lynchburg Trail, a 19th Century thoroughfare. Recorded Texas Historic Landmark, 1968.

4. 27" x 42" Official Texas Historical Marker San Jacinto County - 3-20-72 - (SMF) - State Highway 150, Shepherd.

Town of Shepherd

Originated in vicinity of old Drew's Landing, a Trinity River port for settlers bringing in goods and shipping cotton, tobacco, and other products to markets. An early nearby community was Big Creek.

Into these pioneer settlements came Houston East & West Texas Railroad investors, including Benjamin A. Shepherd (1814-1891) of Houston, who in 1875 platted townsite here, naming it for himself. The town square was on west side of H.E.&W.T., which was completed beyond this point in 1879. The Shepherd post office opened December 22, 1879, with Jack B. Noble as postmaster.

A pioneer physician was Dr. William Herbert Beazley (1837-1919); Mrs. Jessie Fain operated an early hotel; Mrs. Jane Langham taught first public school session in Methodist Church building. James Ephraim Tribe, a native of Canada, came here in 1895, was a carpenter, coffin maker, millwright, and wheelwright. A Baptist, he built a church edifice for that faith in 1896.

Distinguished native son Robert Scott Lovett (1860-1932), became president of Southern Pacific and Union Pacific Railroads and rendered outstanding civilian service to the nation during World War I.

Once a center for the lumbering industry, Shepherd remains an important market town of southeast Texas.

5. 24" x 18" Official Texas Historical Marker San Jacinto County - 12-19-69 - FM 223, 3.5 miles east of Shepherd.

Near Site of Coushatta Indian Village

Inhabited from about 1835 to 1900 by members of the Coushatta tribe. Most of the Indians had small farms, but also worked for wages after crops were harvested. Burial pits excavated by archaeologists (1968) revealed skeletal remains, ironstone dishes, glass beads (obtained in trade with Anglos), ornaments made from silver coins.

6. 14" x 9" Official Texas Historical Grave Marker San Jacinto County - 1-14-70 - grave site, at Jones Bluff, Texas, Highway 190, 4 miles east of Point Blank.

Isaac Jones
(October 4, 1793-May 27, 1878)

Individualistic pioneer of Texas. Born in Mississippi; moved here 1834, receiving Mexican Land Grant on west bank of Trinity River. Served 3 months in army of Texas Republic 1836-1838. Operated ferry at Jones Bluff 1858-1861. Wife: Elizabeth (Martin).
Recorded--1970

7. 27" x 42" Official Texas Historical Marker (SMF) Polk County - 2-25-70 - Lake Livingston, viewing area, 6 miles southwest of Livingston.

Early Roads in Polk County

Travel was of great importance on Polk County's early days. Civilized Indians--particularly Creeks, Alabamas, Coushattas and Kickapoos--were numerous and had many trails for intercommunication. Long King's Trace (named for a chief) led from Alabama villages through site of present Livingston, past site of this marker. The Coushatta Trace began in Louisiana, wound through what is now Polk County, joining (more than 100 miles west) an ancient road into Mexico. The Alabama Trace branched off E. Camino Real (The King's Highway) east of Nacogdoches and came to the site of present Alabama-Coushatta reservation. Indians started many other local roads.

A Mexican-Indian trail became the Nacogdoches-Liberty stagecoach road, after white settlement began in the 1820's. Settlers brought in goods by Trinity River boats, establishing 20 landings (or wharves) on the 72 miles of Polk County riverfront. Roads led to the interior from the landings; boats handled shipping of county produce for many years.

Northeast of Livingston is the "Old Israel Road"--named for a religious colony whose buildings have disappeared. As with many of the Indians, memory of these people is preserved only in the road's name.

8. 18" x 28" Official Texas Historical Marker Polk County - 1-17-69 - at museum, West Church and Drew Streets, Livingston.

Paddlewheels on the Trinity
(Nearest Point on River, 7 Miles Southwest)

Once the most navigable of Texas' winding, debris-choked river, the Trinity links Dallas to Galveston across the rich farm lands of East Texas.

Of 17 landings in Polk County, Smithfield, Drew's Landing, and Swartwout were 3 of the most important. At times, 8 or more steamboats, stern- and side-wheelers could be seen at a busy landing, where stevedores loaded goods as curious citizens hailed the passengers.

Although the Trinity played a leading role in Texas commerce, 1850-1900, railroads eventually ended the steamboat era.

9. 18" x 28" Official Texas Historical Marker Walker County (SMF) - 3-1-68 [Early draft, not final].

Site of Old Bidai Indian Post

Located here in the middle 1830's. The Bidai, who inhabited the Trinity River Valley, were one of several tribes in the Atakapan group.

An agricultural people, the Bidai also hunted buffalo and deer. Their name, which means "Brushwood" may refer to the type of dwelling they built. Like many Indians, they tattooed the face and body.

By 1850 the Bidais, never a large tribe, were almost extinct. As a result of intermarriage, their

descendants (if any) are now on the East Texas Alabama-Coushatta Indian Reservation.

10. 27" x 42" Official Texas Historical Marker Anderson County - 3-4-71 - near intersection of FM 321 and Spur 324 off State Highway 287, in Tennessee Colony.

Tennessee Colony

Founded in 1838 by settlers who came from the old South by wagons, seeking fertile, watered farm lands. Later their cotton shipped from Magnolia Ferry on the Trinity created great wealth. Early businesses were a general store, blacksmith shop, cabinet shop (which made furniture still found in area). Town was trade center for places as far away as Dallas. The plantation era reached a climax in grandeur on the properties of F. S. Jackson, a settler from Virginia.

Circuit riders held religious services in homes until a log cabin church could be built, probably in late 1838; a second log church succeeded this one.

Masons attended the lodge in Magnolia for years, but in 1857 obtained charter for Tyre Lodge No. 198, A.F.&A.M., in Tennessee Colony. They then worked to build a 2-story church-school-lodge hall, which was finished in 1860 (and was to be used until 1948). The schools were outstanding, especially those taught by a Mr. Hooker and by Professor Sidney Newsome. They drew patronage from Palestine and other area towns. Remembered students included Addison and Randolph Clark, later to become founders of a college that would be forerunner of Texas Christian University. Descendants of original colonists still live here.

11. 27" x 42" Official Texas Historical Marker Anderson County (SMF) located at southwest corner of intersection of State Highway 294 and FM 1990; 11 miles southwest of Palestine.

Site of Old Magnolia (One-Half Mile South)

Founded in 1840's as a ferrying point on the Caddo Trace; later became a major landing for flatboats and steamers on the Trinity River, where cotton and other products were shipped by a four-day trip to Galveston to be exchanged for flour, salt, and sugar.

Magnolia--named for a huge tree in center of town--reached its zenith in 1863, when it had several hundred

people and eight major stores. Focus of social life then was Haygood's Magnolia Tavern, where board and lodging for a man and two horses cost $2 a day.

Haygood's was the scene of many gala parties feteing riverboat passengers, for when a deep-throated steamer whistle blew a few miles from port, it signaled a rush of people from miles around eager to greet arrivals and collect long-awaited parcels.

Growing river traffic spawned many towns like this, and from 1830 to 1880, Texas waterways were dotted with boats. From the first, though, the state's rivers were unsuited for extensive trade, because even the largest were shallow, winding, and often choked with debris. After 1880, trains replaced riverboats.

An irony of the transition was that one of the last steamers to pass Magnolia, in 1872, carried rails for the tracks being laid through nearby Palestine.

12. 27" x 42" Official Texas Historical Marker Freestone County (SMF) - 1-18-68 - At old depot, 208 South 3rd Avenue, Teague, Texas.

Old Division Point Office for the "Boll Weevil" Railway

Important Texas transportation artery. Chartered as Trinity & Brazos Valley Railway. Nicknamed for special trains roaring down its tracks, taking men to "Boll Weevil conferences"--in turn of century alarm over pests attacking cotton and the economy. Another nickname for the railroad was "Turnip & Bean Vine."

The T.&B.V. was founded by an investor-statesman, Colonel Edward M. House, famed for his national political power as advisor of U. S. President Woodrow Wilson. House's associates included Frank Andrews, formerly assistant Attorney General of Texas; Robert H. Baker, statesman and insurance executive; and Benjamin F. Yoakum, lifetime railroad man and agriculturalist.

Road was built 1902-1907 from Houston to Cleburne, and with special trackage arrangements it became a short-cut hauler from Galveston to Fort Worth and Dallas. It introduced diesel passenger streamliners to Texas; belonged to Burlington-Rock Island complex during most of its first 60 years of service.

Texas attained a peak of 17,078 miles of railroads in 1933. Trains still have respected roles in freight hauling, but the era of regulating family clocks by passage of the "Boll Weevil" or some other train is now largely a matter of warmly-cherished history.

13. 14" x 24" Official Texas Historical Marker Freestone County - 12-5-69 - grounds of Freestone County Historical Museum, Fairfield.

Butler Church Bell
(Formerly 15 miles SE)

Said to have come from riverboat "S.A. Ruthven," which plied Trinity River until it was sunk in 1873 at Parker's Bluff. Butler Church acquired bell and used it for many years. In 1963, after the church was razed, Mrs. Clay Burkhart purchased bell, donated it to county museum in 1964.

14. 27" x 42" Official Texas Historical Marker Navarro County - 3-24-72 - on FM 416, off U. S. Highway 75, 3 miles northeast of Streetman.

Birdston Community and Cemetery

When V. I. Bird opened a general mercantile store about 2 miles to the northwest in the 1860's, Birdston community was founded. As local economy then depended on cotton, a gin was soon built near the store. In a few years, store and gin were relocated a mile east of this cemetery, at halfway point on main road from Fairfield to Corsicana. The Birdston post office opened December 11, 1866. By 1867 the community also had a school; by 1872 a church building, used by all faiths.

The cemetery was opened on land donated by Edd and Juliett Burleson for church and school purposes. The first grave, located near the church, was that of a child, Mary Rayburn, whose family had been travelling from Fairfield to Corsicana, stopping at Sherrard's boarding house in Birdston, where the child fell ill and died. A second grave was dug near the church when T. J. Gilbert died on December 5, 1872. By 1888 additional cemetery land was sold to trustees by Mrs. Burleson.

When Birdston was bypassed in 1909 by Burlington Rock Island Railroad, it lost its post office and businesses; the school closed in 1920. The cemetery has continued in use through ensuing years, and in the 1950's

a new section annexed by purchase of acreage from the Charley Gregory estate.

15. 18" x 28" Official Texas Historical Marker Henderson County - 6-9-67 - (SMF) located 3 miles north of Trinidad on Highway 274.

The Malakoff Man

A sandstone image of a human head--carved by prehistoric men--was found near here in 1929 by workmen of Texas Clay Products Company. It was dug from gravel pit now under cedar creek lake.

The carving weighed 98 pounds, was 16 by 14 inches, with eyes 2 1/2 inches wide. First stone was found at depth of 16 1/2 feet. Two similar images were unearthed in same area in 1935 and 1939.

Archaeologists date Malakoff "men" as many thousands of years old. Found near the images were fossil remains of extinct horse, elephant, camel species. Images now in Texas Memorial Museum.

16. 14" x 24" Official Texas Historical Marker Dallas County - 5-19-67 - City Park, Dallas, Texas.

California Crossing
(Some Five Hundred Feet North)

Here thousands of 49'ers crossed Trinity River in heroic trek west--following California gold discovery.

Crossing was in shallow part of stream on southern transcontinental route to Pacific. Later used by stage lines, railroad; route passed through Dallas and Cedar Springs on to El Paso.

17. 20" x 20" Official Texas Historical Marker Dallas County - 4-11-68 - Front yard of Park Cities Y.M.C.A. University Park.

Preston Road

Named for Ft. Preston, built 1841 at best ford on upper Red River (north of here). Followed Pre-Columbian Indian trail.

Republic of Texas staked out road to fort from Austin. "Preston Road" later served as cattle trail from ford of Trinity River at Dallas to Oklahoma border.

18. 20" x 20" Official Texas Historical Marker Dallas County - 2-6-68 - Dealey Plaza in Dallas.

Site of First Ferry and Bridge
(About 300 Feet West)

First ferry on the Trinity River at Dallas was started here, 1842, by John Neely Bryan (1810-1877), the founder of Dallas. Alexander Cockrell (1820-1858), early builder and developer, replaced ferry with wooden toll bridge, 1854.

This crossing played an important part in the development of the city.

19. 27" x 42" Official Texas Historical Marker Tarrant County - 3-25-69 - on yard of County Courthouse.

Fort Worth
"Where the West Begins"

Founded June 6, 1849, as frontier post of Co. F, 2nd Dragoons, 8th Dept., U. S. Army. The commander, Major Ripley Arnold, named camp for his former superior officer, Major General William Jenkins Worth. In 4 years of operations, the post had but one serious Indian encounter. A town grew up alongside the port, as center for supply stores and stagecoach routes.

In 1856 Fort Worth became county seat of Tarrant County. A boom started after 1867 when millions of Longhorns were driven through town enroute to Red River crossing and Chisholm Trail. Herds forded the Trinity below Courthouse Bluff, one block north of this site. Cowboys got supplies for the long uptrail drive and caroused in taverns and dance halls.

After railroad arrived in 1876, increased cattle traffic won city the nickname of "Cowtown."

By 1900, Fort Worth was one of the world's largest cattle markets. Population tripled between 1900 and 1910. Growth continued, based on varied multimillion-dollar industries of meat packing, flour milling, grain storage, oil, aircraft plants and military bases. Fort Worth has also developed as a center of culture, with universities, museums, art galleries, theatres and a botanic garden.

20. 27" x 42" Official Texas Historical Marker Tarrant County (SMF).

Founder of World-Famous Cattle Trail
Jesse Chisholm
(1806-1868)

Represented the Republic of Texas and President Sam Houston in many negotiations with Indians. Half Scotsman, half Cherokee; a scout, hunter, trader and trailblazer. Spoke 40 Indian languages and dialects, and was a respected influence among Southwestern tribes including the wild Kiowas and Comanches.

In 1843, near here at Bird's Fort on the Trinity, was interpreter for a peace conference; in 1849 was in negotiations at Grapevine Springs, to the north.

He is best known for marking the Chisholm Trail across Oklahoma and Kansas. Cowboys driving cattle north to seek favorable markets used his direct route which avoided deep rivers and lay in grassy, watered land. He thus helped rebuild Texas economy that had been wrecked in 1861-1865 by Civil War. Cattle had increased greatly in wartime. Texas had no market; drives were necessary, so $5 Longhorns could go to northern markets to bring $30 or more per head. In 1867 the Chisholm Trail was extended to Abilene, Kansas, where cattle loading pens and railroad shipping cars were provided.

This was the best known of several cattle trails from Texas over which some 10,000,000 beeves were driven from the state during the years 1866-1884.

[Incise in base: Erected in commemoration of Chisholm Trail Centennial, 1967.]

CHAPTER II

INVENTORY SURVEY OF GEOLOGICAL ELEMENTS, TRINITY RIVER, TEXAS

by

Hershel L. Jones

with the assistance of:

Volker Gobel
Boyd Dryer
Tom Middlebrook

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SUMMARY

The geological investigation was conducted as part of the interdisciplinary study and covers the geological aspects related to the proposed channelization of the Trinity River.

Channelization of the Trinity River and construction of reservoirs at certain locations will result in the disturbance of inundation of:

*Portions of existing field production and disposal facilities of the Cayuga, Stephens Lake, Bazette, Flag Lake, South Kerens, Carter-Cragg, Stewards Mill, Navarro Crossing, Mapleton, Fort Trinidad, New Ace, South Liberty, and the Lost Lake Oil fields;

*Gas and oil pipelines which are located in the valleys of the Trinity River and its tributaries;

*Potential gravel production areas in the Trinity River Valley including deposits in the Dallas-Fort Worth area, and a sand and gravel pit in operation near Turkey Creek, Henderson County;

*The release of salt water from the salt-polluted holding lake of the Texas Gulf Sulfur Company's sulfur mining operation into the newly created Lake Wallisville;

*The geological type locality of the Eagle Ford Group west of Dallas, Tarrant County and that of the Kerens Member of the Wills Point Formation east of Kerens, Navarro County;

*Possible flooding of the once accepted type locality of the Onalaska Member of the Catahoula Formation, Polk County, by Lake Livingston;

*Several fossil localities along the cliff of the Trinity River northeast of Kerens;

*Possible disturbance of the fossil locality of the Fleming Formation known as Red Bluff, San Jacinto County.

The inundation effects are associated with and followed by:

*Possible pollution of the river and lake waters by oil field brines and crude oil which are commonly retained by present practice in unlined sludge pits or are discharged onto the ground and into creeks. Contamination of the river and lake waters by brines results in a considerable increase in the water salinity. Density stratification of the water in the reservoirs is possible, the denser saline water forming the lower water layer in the lake basin which causes anaerobic, toxic conditions. Salinity causes also an increase in flocculation and sedimentation of clay minerals. Oil has harmful effects on plant and animal life, and causes pollution of the shoreline area.

*The overall decrease in water quality requires extensive purification for drinking water production, and occasional flushing of the reservoirs which, however, may have harmful effects downstream.

*The discharge of sediments by the tributaries into the shallow water sub-basins of the reservoirs causes their progressive silting-up which is also promoted by the possible increased salinity of the water of the lakes.

*Surface runoff from the salines on Butler and Palestine salt domes may contribute salt to the Trinity River and ultimately to the Livingston Reservoir.

*Salt-contaminated discharge water from the Texas Gulf Sulfur Company's mining operation may be indirectly contributing salt to the Trinity River and will directly contaminate the future Wallisville reservoir waters.

*Possible acid water pollution of the Trinity River occurs as a result of the sandstone quarrying operations of the East Texas Stone Company on the northern flank of the Butler Dome.

*Lignite is strip-mined on a large scale north of Fairfield, Freestone County, and is used for electric power generation in the new Big Brown Steam Electric Station northeast of Fairfield. Apparently, sulfur dioxide gas and possibly mercury vapor will not be removed from the stack emissions. This results in a considerable sulfur dioxide and mercury emittance. Dispersal of the emissions by prevailing southwest-northeast winds results in adverse effects in the downwind areas including pasture land, the reservoir, and its drainage area. An increase in the acidity of the surface water is also possible.

*The practice of burning undesirable amounts of sulfur-containing gas releases sulfur dioxide gas directly into the atmosphere.

*Disposal of large amounts of channel excavation material could be accomplished by the building-up of shallow lake areas.

*Gravel, sand, and clay deposits in the region could be utilized for construction purposes.

*Aquifers occur throughout the Trinity River Basin. Channel alignment will probably have little effect on these but the initial effect of the impoundment on these adjacent to the reservoir areas will be the reversal of the water table slope away from the reservoirs. This reversal coupled with artificial recharge from the reservoirs results in an increase in the water level in adjacent aquifers. Seepage and ponding is most likely to occur in the areas of Catfish Creek and the city of Trinidad.

INTRODUCTION

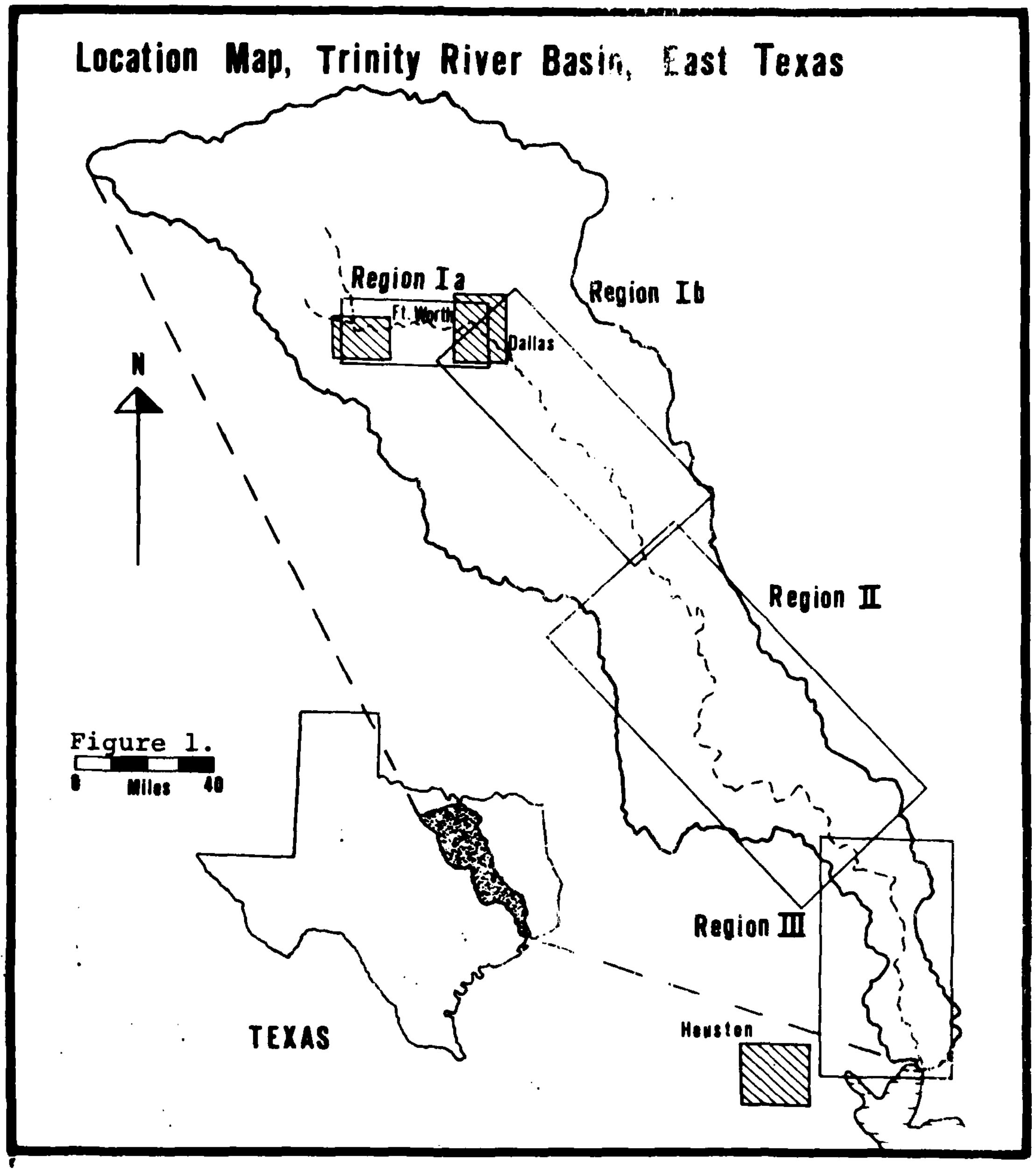
This report is the result of an inventory geologic study of that portion of the Trinity River Basin from Fort Worth to Wallisville which will be affected by the channelization and lock and dam construction activities by the United States Army Corps of Engineers.

The geology and the impact of the channelization and damming within the Trinity River Basin were to be considered briefly in order to identify areas requiring in-depth studies. The geological conditions, the possible changes, and the related environmental aspects were considered.

Due to the Trinity River Basin's large areal extent and differences in geology and geography, the basin has been divided into three regions to facilitate discussion (Figure 1).

Region I includes the upper portion of the basin from Fort Worth to the lower end of the Tennessee Colony reservoir. Region I is further subdivided into the area Ia, Fort Worth-Dallas; and the area Ib, Dallas-Tennessee Colony reservoir.

Region II extends from the Tennessee Colony reservoir to Lake Livingston.



Location Map, Trinity River Basin, East Texas

Figure 1.

Region III constitutes the area between Lake Livingston and Wallisville.

GEOLOGICAL SETTING

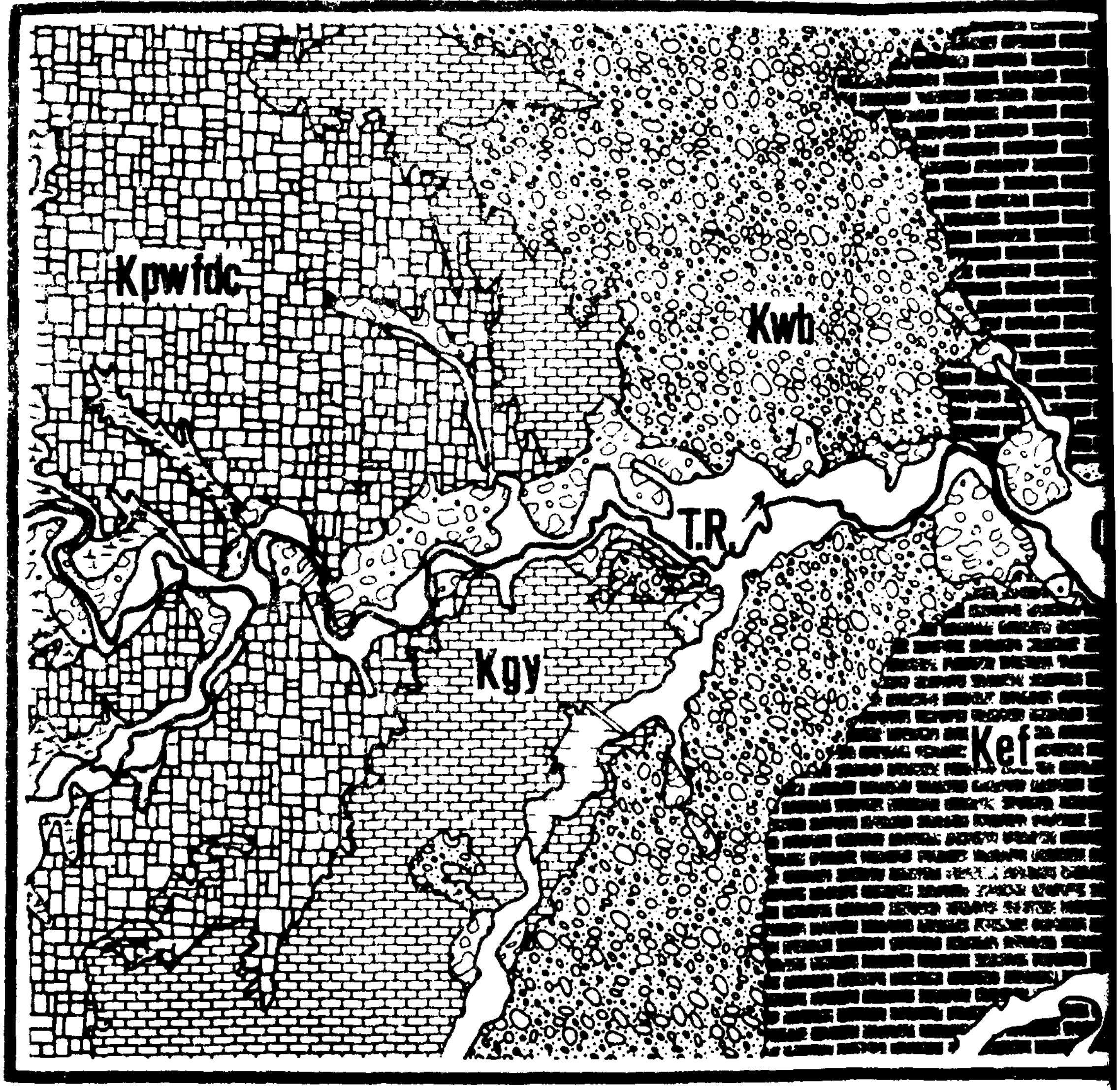
The Trinity River drainage basin lies entirely within the Coastal Plain Physiographic Province, a more or less gently undulating plain bordering the Gulf of Mexico. Strata underlying the plain dip to the southeast at a slightly steeper angle than the present land surface. This results in a series of outcrop belts essentially parallel to the present coastline. Differential erosion of alternating resistant and less resistant rocks in this tilted sequence has produced a series of low, landward facing escarpments which break the gentle seaward slope of the land.

Generalized geological maps are given in Figures 2, 3, 4, and 5. Rocks of the Trinity River drainage basin are of sedimentary origin and their character reflects the various depositional phases and environments during Pennsylvanian, Cretaceous, Tertiary, and Quaternary geologic times. They consist of shales, sandstones, chalks, marls, and unconsolidated clastic sediments such as clay, silt, sand, gravel, and range in age from Pennsylvanian to Quaternary. In the northwestern part of the basin the Upper Cretaceous rocks onlap unconformably on older strata of Pennsylvanian age. The beds of Pennsylvanian age dip to the northwest while the successively younger Mesozoic and Cenozoic sediments dip to the southeast. The rate of dip and the thickness of the rock units increase in downdip direction.

Region I

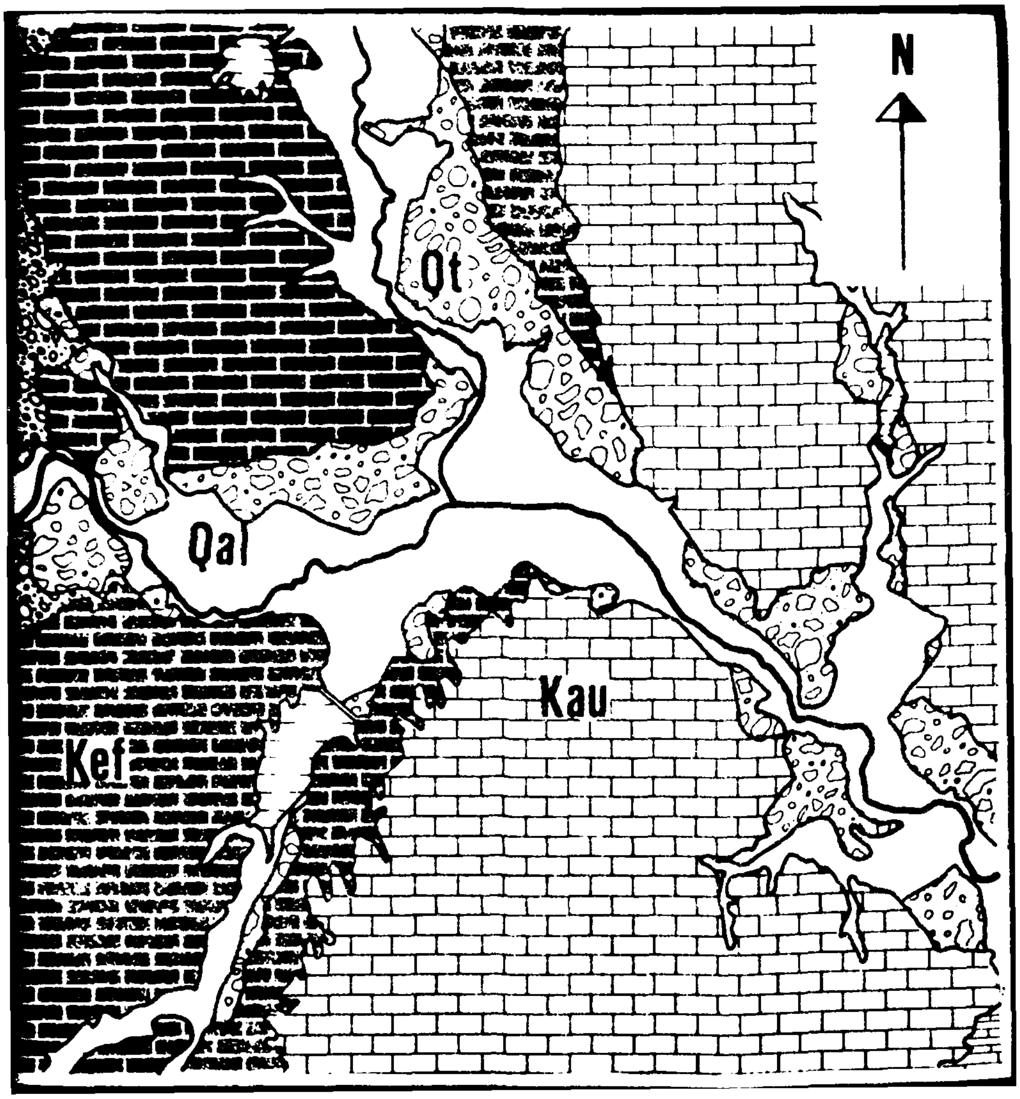
The formations exposed in Region I are of Cretaceous, Tertiary, and Quaternary age. The oldest rocks exposed are Cretaceous, and extend from the Fort Worth area to the Mexia-Talco fault zone which crosses the Trinity River northeast of the town of Corsicana. Tertiary and younger formations extend from there on to the Gulf of Mexico.

The sediments in the eastern and southeastern part of Region I are positioned at the western and northwestern portion of a depositional basin referred to as the East Texas Embayment. Its axis forms a gradually eastward curving arc extending northward from the mouth of the embayment in the north central part of Houston County.



GENERALIZED GEOLOGICAL MAP, REGIO

Figure 2.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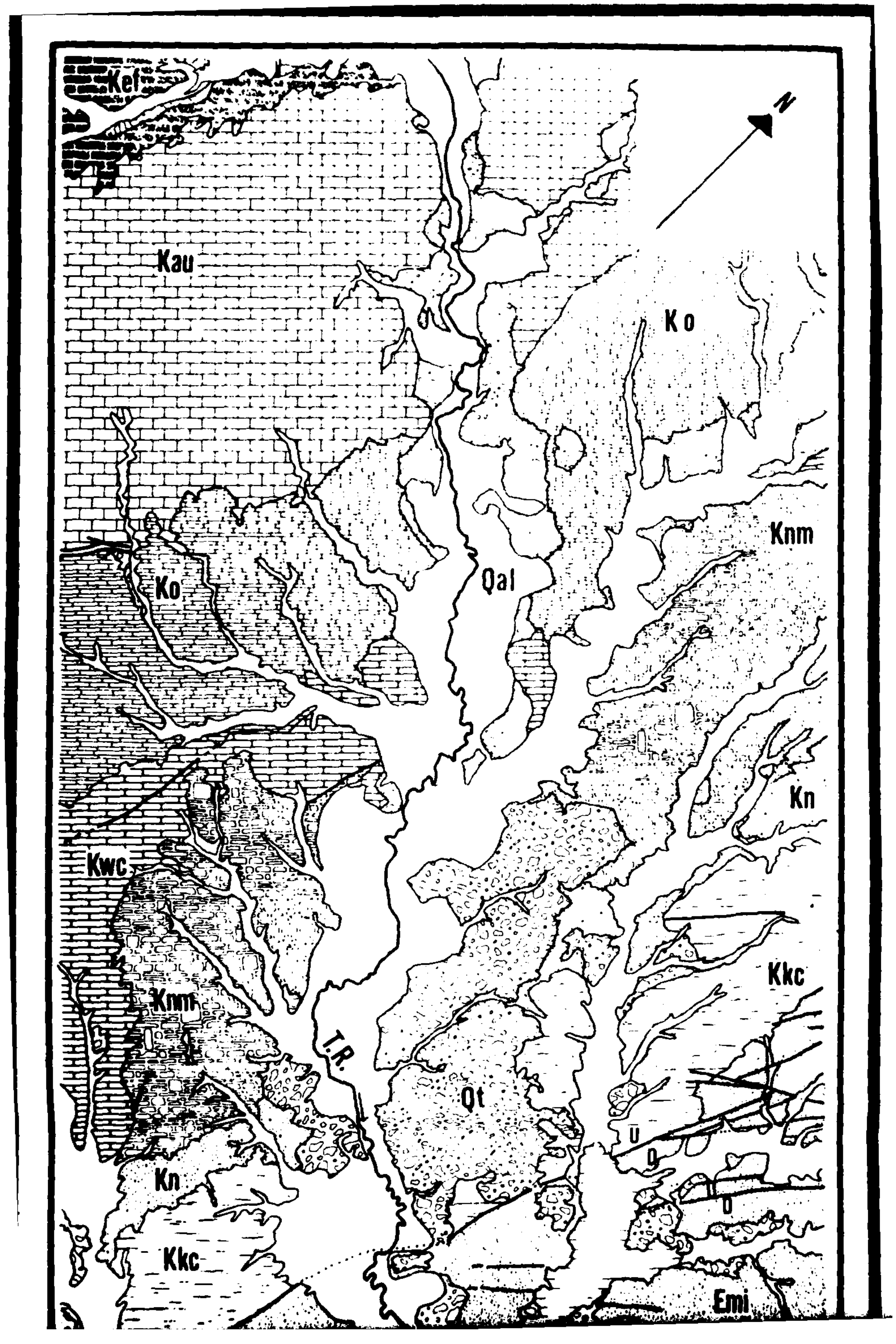
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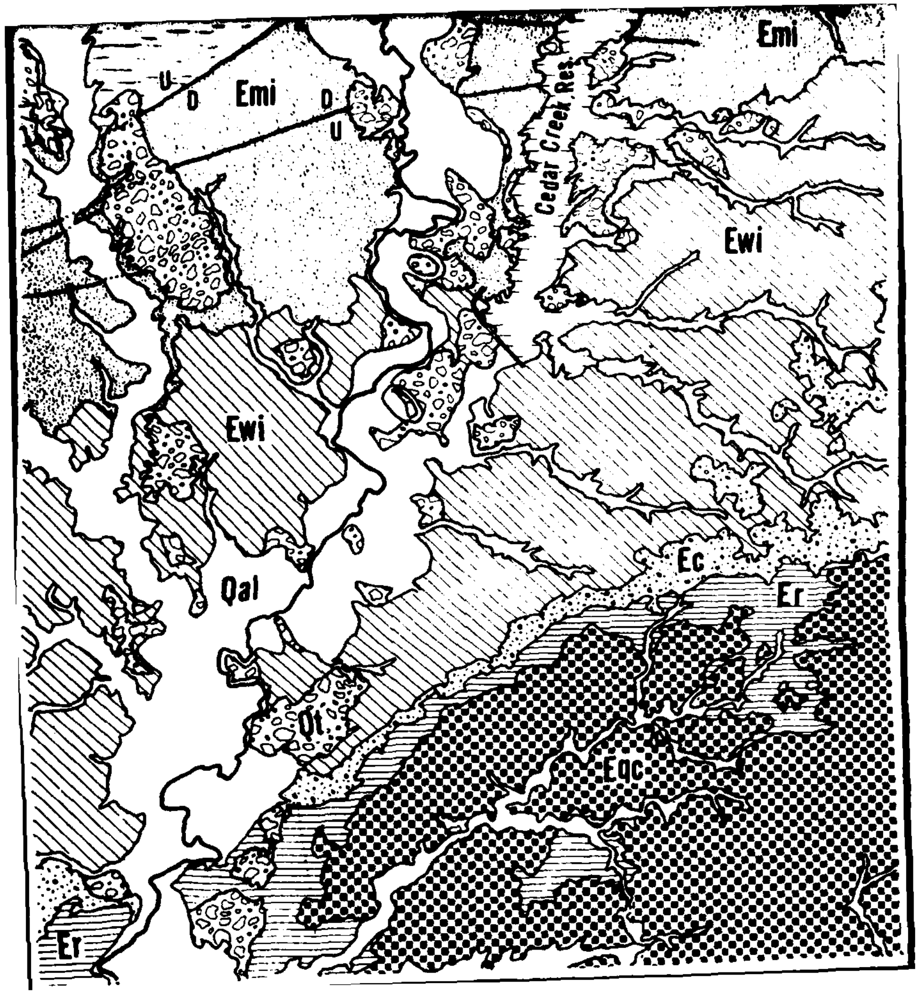
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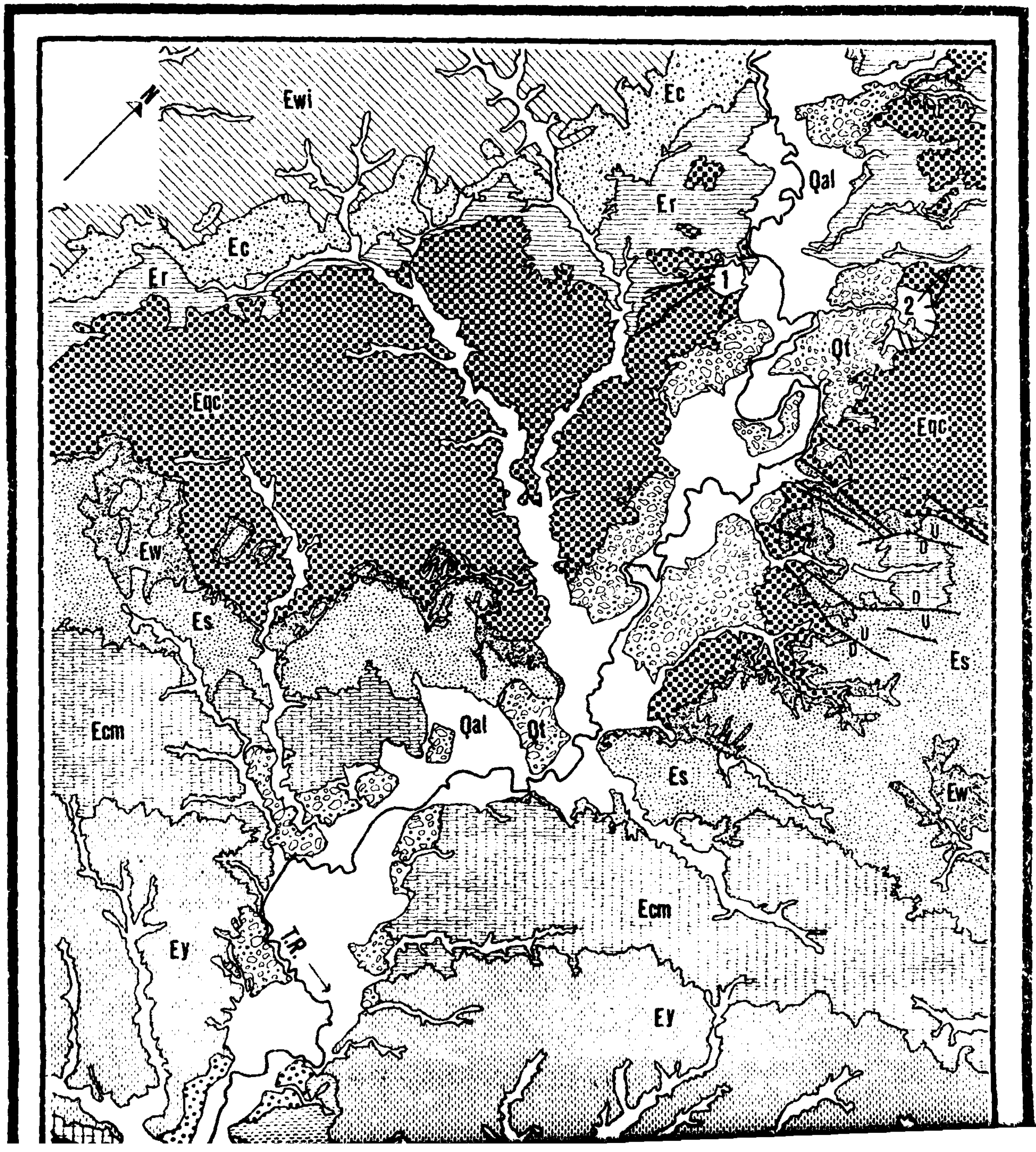

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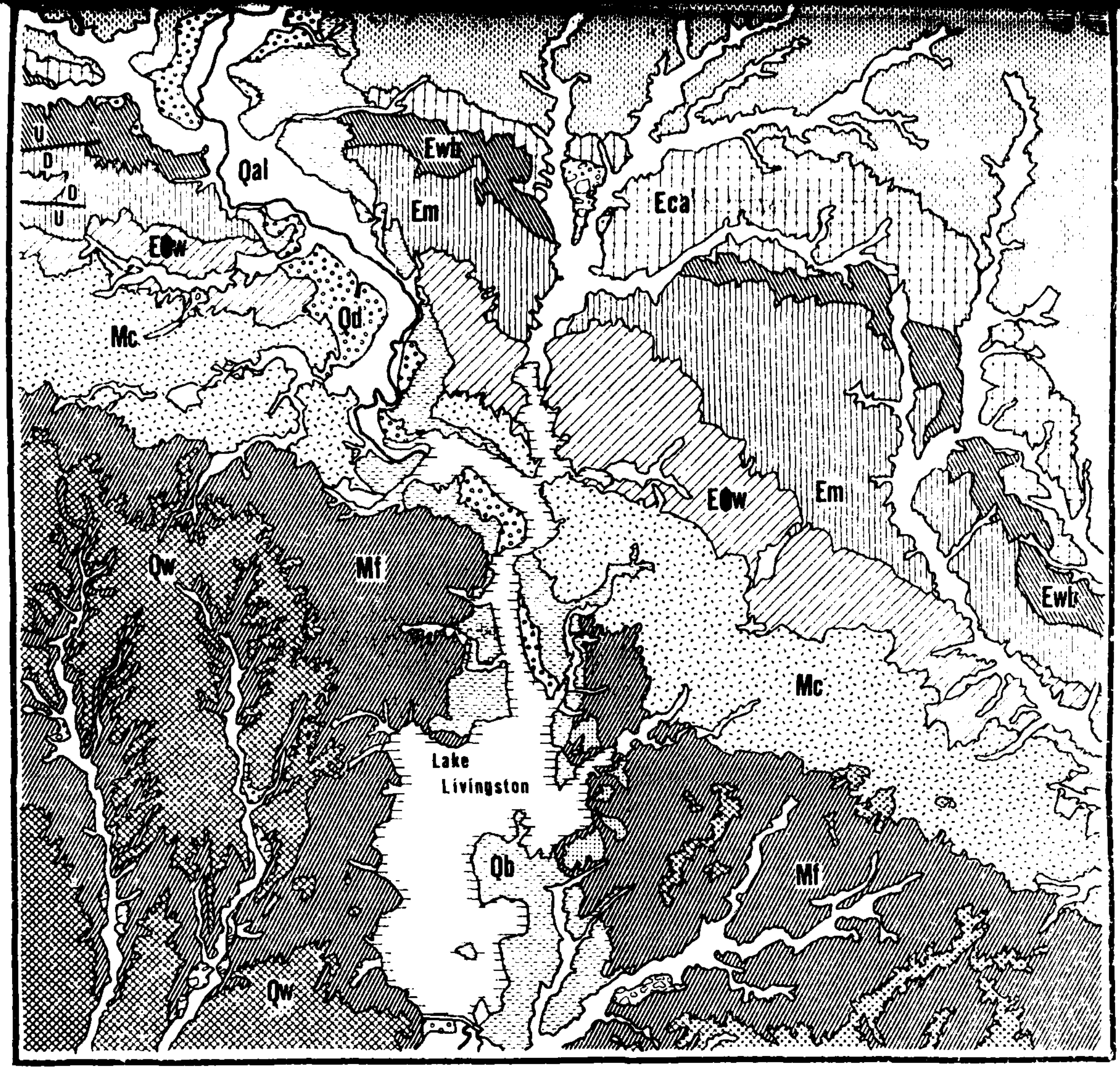


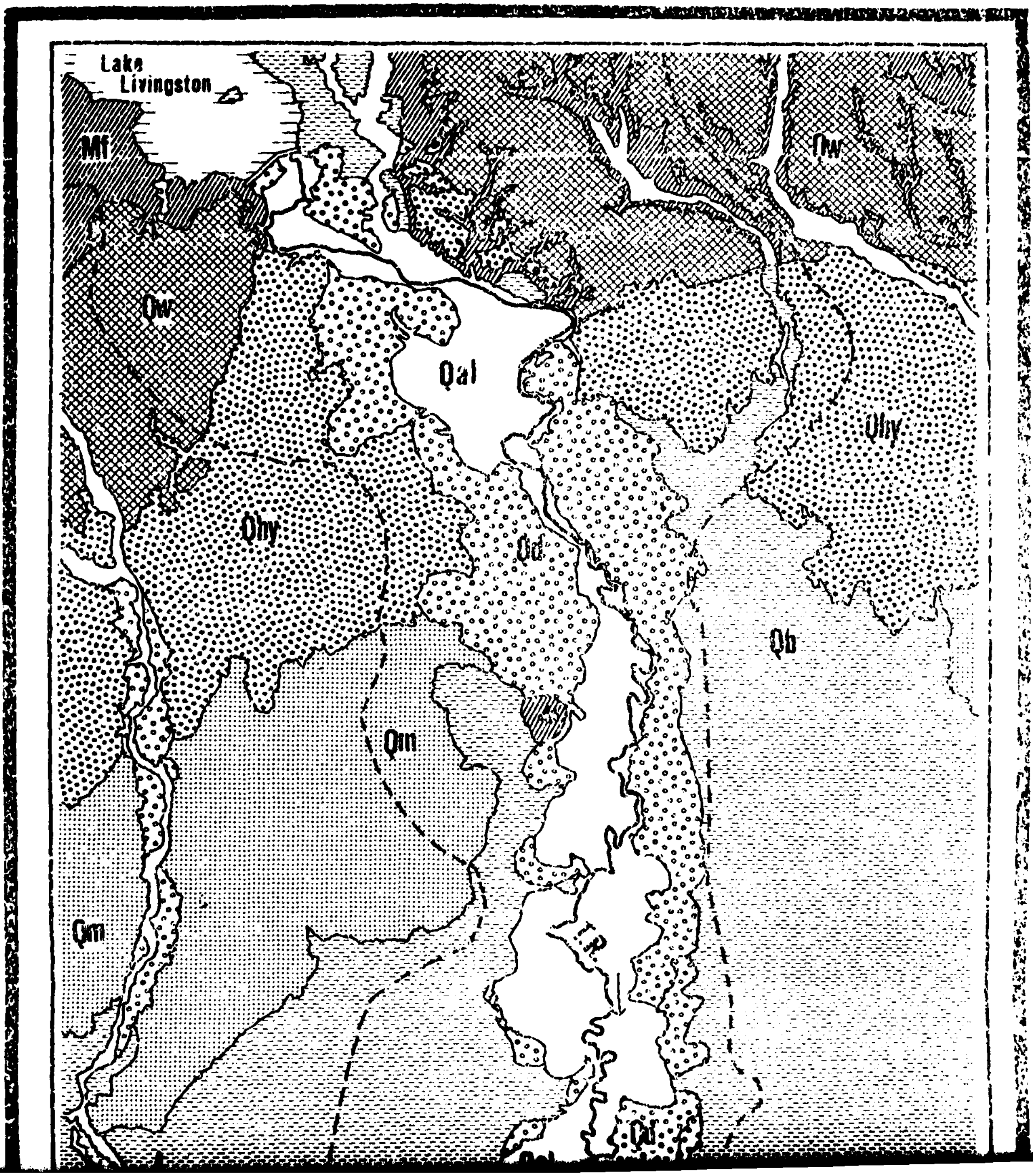
GENERALIZED GEOLOGICAL MAP,

REGION II, TRINITY RIVER BASIN

0 Miles 10

Figure 4.

Geology compiled from
Geological Atlas of Texas.


Lake Livingston
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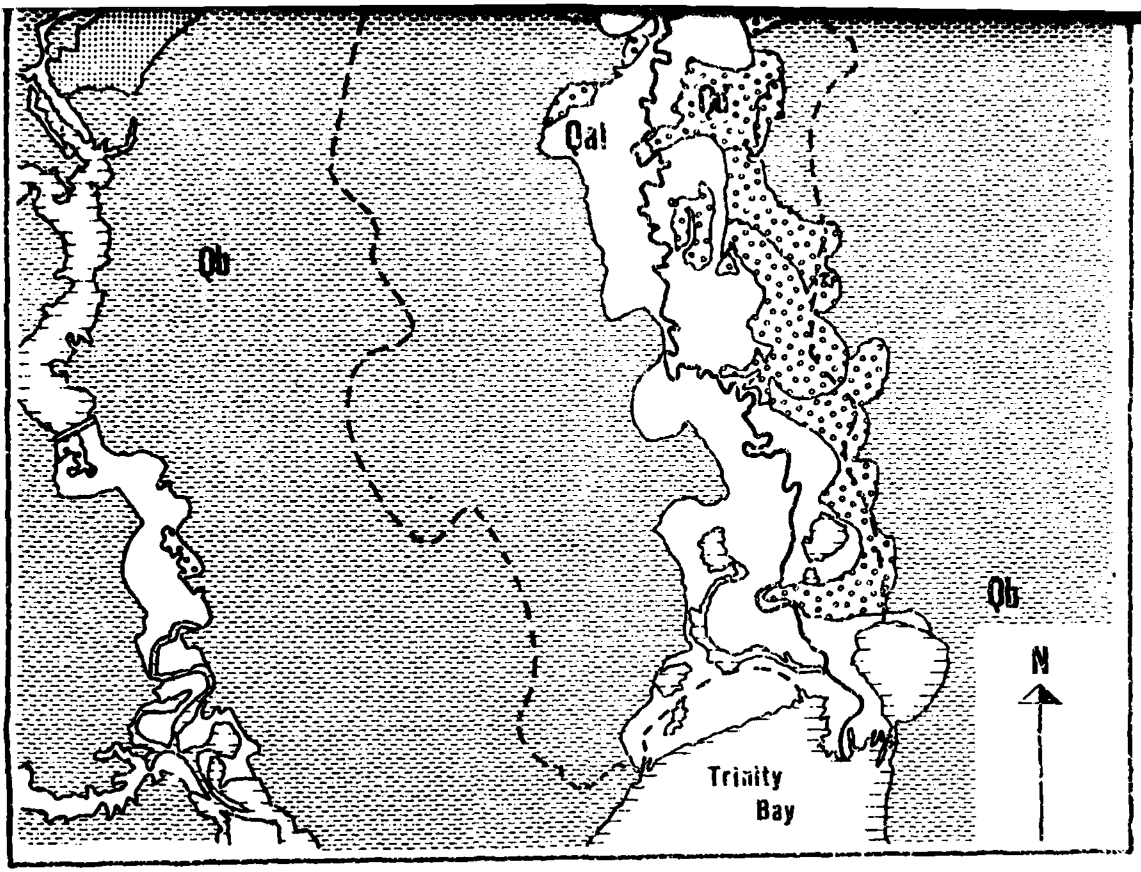

GENERALIZED GEOLOGICAL MAP,
REGION III, TRINITY RIVER BASIN

0 Miles 10

Figure 5.

Geology compiled from
Geologic Atlas of Texas.

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basin. The thickness of the rock units commonly increases towards the basinal deep.

The uniformly dipping strata are disturbed at many places by numerous salt domes situated close to the basin axis (e.g., the Bethel dome). The salt masses were mobilized from bedded salt deposits at greater depths (Louann Salt) and ascended through the overlying sediments. They displaced the country rock producing diapiric structures which frequently serve as oil and gas traps.

Major displacements of the sedimentary strata took place along abundant faults which dip to the northwest and the southeast. The faults form a system of en échelon faults and grabens called the Mexia-Talco fault system. It trends along the western part of East Texas in a north-south direction and swings to an easterly direction in the northern part, thus framing the East Texas Embayment.

Region II

Rocks of Tertiary and Quaternary age crop out in the central and southern parts of the Trinity River Basin and dip in a general southeastward direction. These rocks consist of an alternating sequence of marine and continental deposits which were formed as a result of repeated transgressions and regressions of the sea during these periods of geologic time. The sediments are mainly composed of clay, shale, marl, sand, and lignite.

The sediments in the eastern portion of the northern part of Region II are positioned at the western edge of the East Texas Embayment and dip southeast into this basin. In the southern part of Region II the rocks dip southeastward toward the Gulf of Mexico.

In Region II, shallow salt domes (e.g., the Palestine and Butler domes) disturb the uniformly dipping strata. These domes have brought Cretaceous rocks to the surface that normally occur at greater depths in this area.

In the northern part of Region II a series of en échelon faults and grabens referred to as the Mt. Enterprise-Jarvis-Elkhart fault system, displace the strata up to 500 feet at the surface. This system is located to the south of the Mexia-Talco fault system and roughly parallels it. It marks the boundary between the inland and shoreward parts of the East Texas Embayment.

Region III

The Upper Tertiary and Quaternary rocks of Region III dip southwestward toward the Gulf of Mexico. A few coastal salt domes exist that locally influence the structural pattern of the sedimentary formations.

STRUCTURE

The geological structures in the Trinity River drainage basin are, in general, simple and local deformation has disturbed the strata only in several places.

Region I

In the northwestern part of Region I, rocks of Pennsylvanian age dip regionally toward the north and the Upper Cretaceous rocks onlap unconformably on the older strata of Pennsylvanian age and dip to the southeast.

Structural deformation of the gently southeasterly dipping strata took place in the southern part of the region. Numerous faults and grabens of the Mexia-Talco fault system cross Navarro, Henderson, and Van Zandt Counties. One graben structure intersects the Trinity River Valley between Corsicana and the Cedar Creek reservoir. Sediments of the Midway Group are faulted against Cretaceous rocks. The faults of the system appear to be inactive and concealed. They have apparently no significant surface expression in the area of the basin.

The Bethel salt dome in Anderson County is the only mushroom-shaped diapir structure in this region. It serves as a structural trap for oil and gas.

Region II

Structural contours in Region II roughly parallel the present Gulf Coast. The rock units dip regionally to the south-southeast. This trend is disrupted in the northern part of the region by numerous faults and grabens of the Mt. Enterprise-Jarvis-Elkhart fault system. Surface displacements along the faults of up to 500 feet occur, faulting rocks of the Sparta Formation against rocks of the Cook Mountain Formation.

Faults and grabens of this en echelon system extend west from along the Panola-Shelby County line to southern Rusk and central Cherokee Counties and continue southwestward through Anderson, Houston, and Leon Counties. These faults appear to be presently inactive with no surface expression.

Numerous salt domes occur in the region, most of which are associated with the East Texas Embayment axis or the Elkhart fault system. As examples the Keechi, Palestine, and Butler diapirs can be mentioned. These domes have brought Upper Cretaceous rocks to the surface and are highly faulted. Presently, oil or gas are not produced from these domes but some of the other domes in the region are productive.

Region III

The strike of the strata in Region III is essentially parallel to the present Gulf Coast, and their dip is regionally south-southeast. Major fault systems are not present in the area, but minor faults exist locally which are frequently associated with the salt domes.

In this region, salt domes are classified as coastal domes, in contrast to the interior domes of Regions I and II. The cap rock of one dome, the Moss Bluff dome, has been mined for sulfur since the year 1948.

GEOMORPHOLOGY

The physiographic picture of the Trinity River Basin is extremely variable, featuring treeless prairies, rolling hills, and broad valleys. The altitude ranges from zero at the mouth of the river to about 1,400 feet in the upper reaches of the basin, north of the project area.

Region I

The physiographic expression of Region I consists of a series of north-trending linear belts of alternating treeless Prairies and rolling timbered hills. The belts are parallel to the present strike of the geologic formations, and the physiographic expression is controlled by the susceptibility of the different types of rocks cropping out at the surface. Topographically, the western part of the region is more rugged and varied than the

eastern part with resistant rocks forming prominent westward facing escarpments in some areas. This region is highly dissected by the Trinity River and its numerous tributaries.

Region II

The extreme northern part of Region II lies within the blackland prairie characterized by gently rolling topography. The remainder of the region lies principally in the region of the East Texas timberland which is characterized by gently rolling topography with relief generally of 100 to 200 feet. In the southwest corner of the region small areas of prairie land exist.

Region III

Region III lies mostly in the East Texas timberland which is characterized by gently rolling to hilly topography and heavily forested land. The lower part of the region is located in the flat Coastal Prairie area.

STRATIGRAPHY

Rock formations outcropping in the project area range in age from Cretaceous to Recent and dip south-southeast. They consist predominantly of interlayered clay, silt, sand, gravel, and lignite beds.

A condensed petrographic description of the formations in the project area is given in Table 1 which lists the formations in an order which reflects their increasing age.

Region I

The strata exposed are mainly of Cretaceous age, but some Tertiary and Quaternary sediments are also present. They consist mainly of typical nearshore and marine shales, sandstones, chalks, marls, and also sand and gravel.

The type locality of the Eagle Ford Group lies within the Trinity River Valley approximately 6 miles west of Dallas.

Table 1. Generalized Stratigraphy of Sediments and Sedimentary Rocks, Trinity River Basin, East Texas.

System	Series	Group	Stratigraphic Unit	Approx. Thickness (feet)	Physical Characteristic of Rock Unit
Quaternary	Recent		Alluvium		Unconsolidated clay, silt, sand and gravel deposits.
	Recent or late Pleistocene		Deweyville Formation	0-50+	Unconsolidated clay, silt, sand and gravel deposited at a level slightly above present floodplain.
	Pleistocene		Fluviatile Terrace Deposits	0-80	Unconsolidated clay, silt, sand and gravel terrace deposits in river valley. Three distinct terraces are recognized and may be in part correlative to Beaumont Formation.
			Beaumont Formation	100±	Unconsolidated clay, silt and sand.
			Montgomery Formation (Upper Lissie)	100±	Clay, silt, sand and some siliceous gravel; locally calcareous.

Table 1. Continued

Quaternary	Pleistocene		Bentley Formation (Lower Lissie)	100±	Clay, silt, sand, and minor amounts of gravel.
Tertiary	Pliocene		Willis Formation	100±	Clay, silt, sand, and some siliceous gravel.
			Goliad Sand	0-500	Sand, gravel, calcareous sandstone; interbedded clay.
	Miocene		Fleming Formation	1,300-1,450	Clay, silt, and sand; clays commonly calcareous.
			Catahoula Formation	250-300	Mudstone and sand, tuffaceous. Lower portion of formation quartz sand. Fossil wood abundant.
	Eocene or Oligocene		Whitsett	30-70	Quartz sand, fine to medium grained, tuffaceous, lignitic.
		Jackson	Manning Formation	250±	Quartz sand and clay, lignitic. Fossil wood abundant.

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Table 1. Continued

Tertiary	Eocene	Jackson	Wellborn Formation	50-150	Quartz sand, fine to very fine grained, glauconitic and lignitic, with interbeds of lignitic clay. Locally marine megafossils.
			Caddell Formation	50-150	Quartz sand and clay; clay sandy and lignitic; sand glauconitic.
		Claiborne	Yegua Formation	600-1000	Clay, quartz sand and lignite. Upper portion of formation mostly clay, lower portion mostly sand. Marine megafossils.
			Cook Mt. Formation Stone City Formation	450-470	Clay, marl and sand; lignitic, glauconitic with some limestone lentils.
			Sparta Sand	200±	Quartz sand, fine to very fine grained with lignitic clay and silt partings.
			Weches Formation	50-90	Glauconite, glauconitic marl and quartz sand. Marine megafossils.

Table 1. Continued

Tertiary	Eocene		Queen City Sand	325±	Quartz sand, fine grained, with interbeds of clay, clay ironstone beds, and concretions common.
			Reklaw Formation	30-130	Marquez member: clay and silts; carbonaceous, glauconitic, clay ironstone with imprints of marine megafossils. Newby member: glauconite, quartz sand, clay; marine megafossils.
			Carrizo Sand	60-150	Quartz sand; upper portion fine grained with some clay and silt interbeds; lower portion fine to medium grained.
		Wilcox	Undivided	2000±	Quartz sand, silt, clay, carbonaceous clays and lignite; fossil wood.
		Midway	Wills Point Formation	500±	Clay and silt; silt increases upward, local occurrences of lignite and calcareous concretions. Formation becomes glauconitic near base.

Table 1. Continued

Tertiary	Eocene	Midway	Kincaid Formation	180±	Clay; glauconitic, calcareous, silty or sandy. Phosphatic near base, and some thin limestones occurring near top of formation.
Upper Cretaceous	Gulfian	Navarro	Kemp Clay and Corsicana Marl	Undivided 550±	Clay and marl; silty, sandy, calcareous, glauconitic, locally gypsiferous.
			Nacatoch Sand	200±	Sand and sandy shale; locally cemented to form calcareous sandstone; glauconitic marine megafossils.
			Neylandville Formation	140±	Clay; calcareous, locally sandy, glauconitic and fossiliferous. Some concretionary beds.
		Taylor	Marlbrook Marl (Upper Taylor marl)	400±	Marl and clay; chalky.
			Wolf City Formation	250±	Alternating sandy, calcareous clay; marly sand and thin beds of calcareous sandstone

Table 1. Continued

Upper Cretaceous	Gulfian	Taylor	Ozan Formation (Lower Taylor marl)	550±	Marl and clay; sandy, calcareous.
		Austin	Austin Chalk	700±	Limestone; basal 150 feet of formation consists of massive chalk layers separated by thin shaly layers. Middle portion 250 feet, characterized by thick shaly limestone layers. The uppermost portion contains more shale and less chalk.
		Eagle Ford	Arcadia Park Shale	100±	Clay, shale and limestone. Basal portion clay, separated from upper shaly portion by thin limestone flags. Numerous calcareous concretions in upper portion.
			Britton Shale	320±	Clay marl and shale with some limestone seams, calcareous concretions, and bentonite seams. Lower 20 feet (Tarrant Member) consists of sandy clay, limestone and calcareous concretions.

Table 1. Continued

Upper Cretaceous	Gulfian	Woodbine	Lewisville Formation	250±	Sandstone, sandy clay and clay.
			Dexter	100±	Sandstone, sand and clay; fossil plant remains.
Lower Cretaceous	Comanchean	Washita	Grayson Marl	75±	Shale and marl with thin limestone layers in upper portion of formation. Marine megafossils.
			Main Street Formation	30±	Limestone, chalky massive to medium beds separated by thin shale layers. Marine megafossils.
			Pawpaw Formation	20±	Shale, calcareous, sandy near base, Thin, sandy limestone layers present in the basal beds.
			Weno Limestone	55±	Limestone predominant in upper half of formation, shale in lower half. Locally poor to abundant marine megafossils.
			Denton Clay	35±	Clay, calcareous, locally sandy or silty. Marine megafossils.

Table 1. Continued

Lower Cretaceous	Comanchean	Washita	Fort Worth Limestone	30±	Limestone; chalky, limestone beds separated by thin layers of calcareous shale. Marine megafossils.
			Duck Creek Limestone	50±	Upper 2/3 of formation consists of marl and calcareous shale interbedded with limestone. Lower 1/3 massive limestone.
			Kiamichi Clay	30-50	Clay, silty, calcareous, minor amounts of thin limestone lentils. Marine megafossils.
		Fredericksburg	Goodland Limestone	120±	Limestone with alternating marl and clay beds. Marine megafossils.

Region II

Sediments of Tertiary and Quaternary age are present in this area. Repeated transgressions and regressions during the Tertiary and Quaternary Periods resulted in the formation of an alternating sequence of marine and continental deposits. Clay, shale, and marl, with minor amounts of sand characterize the marine sediments while the continental and nearshore deposits consist of sand and lesser amounts of clay, shale, and lignite.

The type locality of the Kerens Member of the Wills Point Formation is located east of Kerens, Navarro County, on the western side of the Trinity River.

Region III

In this region, Quaternary sands and clays form an outcrop belt parallel to the present Gulf Coast. They are classified into six main formations consisting of unconsolidated Pleistocene sediments of diverse origin including non-marine and marginal marine deposits.

The sediments form coastal terraces which are believed to be in part correlative to the inland terraces of the Trinity River.

PALEONTOLOGY

Sediments exposed in the Trinity River Basin contain a diverse flora and fauna. The latter consist mainly of marine invertebrates. Some fossils occur in Pleistocene river terraces and also in coastal terraces. They consist mainly of vertebrate remains and some invertebrate species of pulmonate gastropods, fresh water pelecypods and ostracods which were deposited in non-marine, deltaic, and fluvial depositional environments.

Region I

The type locality of the Eagle Ford Group lies in the Trinity River Valley, approximately 6 miles west of Dallas and has yielded plesiosaur and mosasaur remains.

The type locality of the Kerens Member of the Wills Point Formation is located east of Kerens, Navarro County. Several fossil localities are also located along the

cliffs of the Trinity River northeast of Kerens and will be flooded. The lithology of the strata is discussed in preceding Table 1.

Region II

The type locality of the Onalaska Member of the Catahoula Formation is located in Rocky Creek east of Onalaska, Polk County. Good exposures also occur in Kickapoo Creek of which Rocky Creek is a tributary. The geologic significance of this locality is in question because some geologists no longer recognize it as a type locality. The possibility also exists that the outcrop has already been inundated by Lake Livingston.

A fossil locality of the Fleming Formation known as Red Bluff and located on the Trinity River in San Jacinto County has yielded vertebrate remains. The exact location of this locality has as of now not been determined but it was mentioned that it is on the James Rankin Survey.

Region III

No known significant type sections or unique fossil localities are known to occur in Region III of the project area.

GROUNDWATER

Major aquifers of the Trinity River Basin are the Trinity Group, the Carrizo-Wilcox, and the Gulf Coast aquifers. Minor aquifers are the Woodbine, Queen City, and Sparta Formations. In general, the groundwater moves toward the Trinity River. It is under water table conditions in the outcrop areas and under artesian conditions in the downdip portions of the strata.

Figure 6 shows the outcrop areas of these aquifers. The geologic units, their ages, and the hydrologic equivalents are given in Table 2. Beginning with Region I, the general groundwater conditions of each region are discussed.

Region I

The primary aquifer of Region I is the Trinity Group of Cretaceous age; the Woodbine Group is a secondary

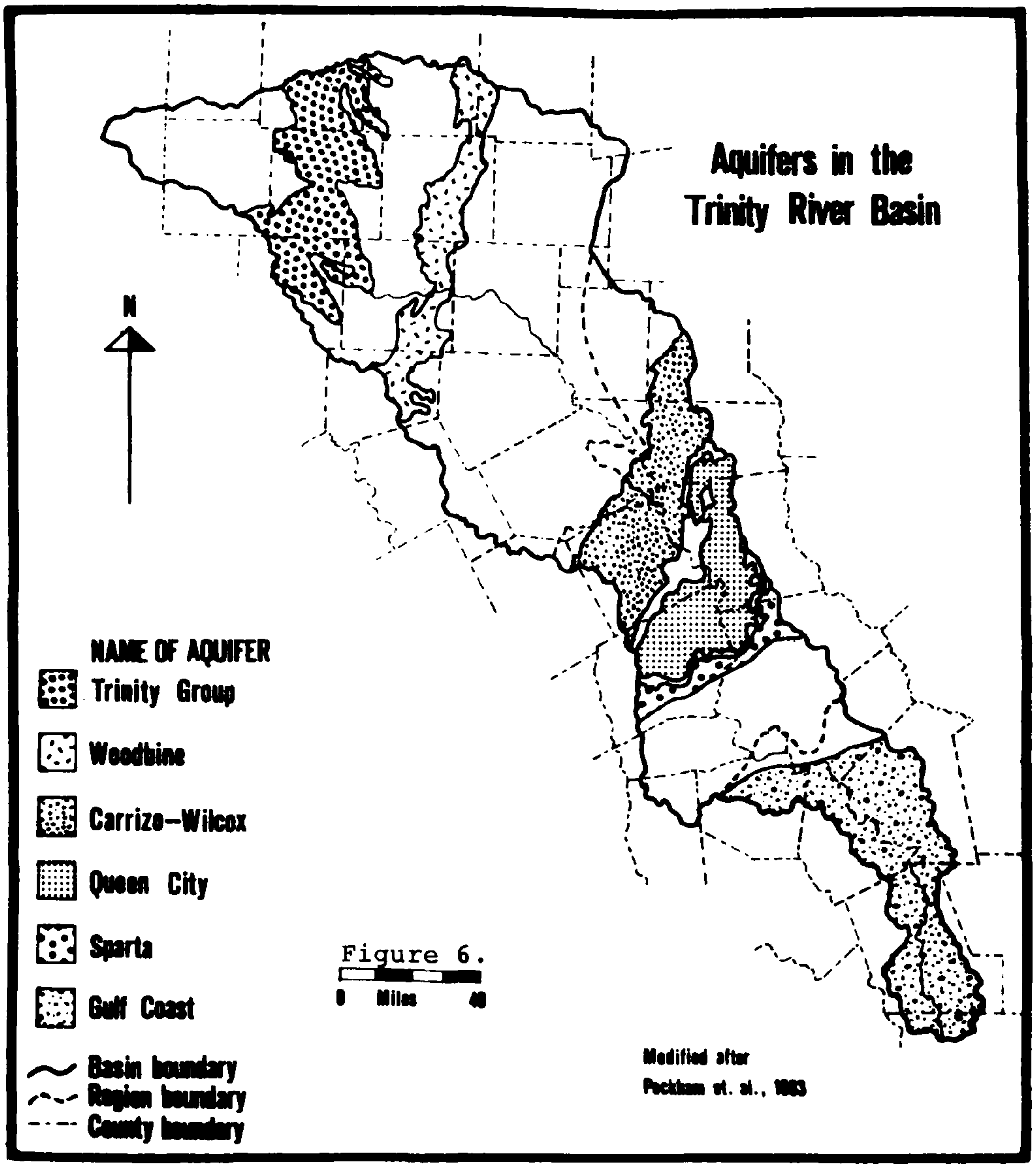
Aquifers in the Trinity River Basin
N
NAME OF AQUIFER
Trinity Group
Woodbine
Carrizo–Wilcox
Queen City
Sparta
Gulf Coast
Basin boundary
Region boundary
County boundary
0 Miles 40
Modified after Peckham et. al., 1963

Figure 6.

Table 2. Geologic-hydraulic Units, Trinity River Basin

Age	Name of Stratigraphic Unit		Name of Aquifer		Name of Aquiclude
Quaternary	Alluvium				
	Beaumont Clay				
	Lissie Formation		Chicot	Gulf Coast Aquifer	
	Willis Sand				
Tertiary	Goliad Sand		Evangeline		
	Lagarto Clay				Burkeville
	Oakville Sandstone		Jasper		
	Catahoula Sandstone				
	Cook Mountain				
	Sparta		Sparta		
	Queen City		Queen City		
	Reklaw				
	Carrizo Wilcox		Carrizo-Wilcox		
Cretaceous	Woodbine	Paluxy	Woodbine		
	Trinity Group (undiff.)	Glen Rose			
		Travis Peak	Trinity Group		

aquifer. Rocks of Pennsylvanian age (undifferentiated), the Nacatoch Formation, and Alluvium are other aquifers that presently yield small to moderate quantities of water locally for municipal, industrial, irrigation, and domestic and livestock use.

Trinity Group Aquifer

The Trinity Group aquifer is exposed at the surface in the northwestern part of Region I and covers most of the upper part of the basin from Wise County through Ellis County. The massive sand unit of the Trinity Group (undifferentiated) splits in down-dip direction into two sands, the Travis Peak Formation and the Paluxy Formation which are separated by the Glen Rose Limestone. Yields from the large-capacity wells in the Trinity Group average about 430 gallons per minute but some reach as much as 2,200 gallons per minute (Texas Water Development Board, June, 1966).

Limited data concerning the movement of groundwater in the Trinity Group indicate that the water moves generally in an easterly direction approximately at right angles to the strike of the beds. Local variations in the direction of movement result from cones of depression that have been caused by pumping, especially in Tarrant and Dallas Counties. The rate of groundwater movement in the Trinity Group is probably on the order of a few feet to a few tens of feet per year.

The Trinity Group (undifferentiated) consists of fine sand of fairly low permeability. Coefficients of transmissibility determined are variable over the area which is in part due to lensing and interbedding of sand and clay. Reported values average approximately 10,000 gpd/ft*. The coefficients of permeability range from 5 gpd/ft^2 to more than 100 gpd/ft^2.

The Travis Peak unit is also characterized by fine sand of fairly low permeability. Coefficients of transmissibility range from 2,600 to 28,000 gpd/ft. Coefficients of permeability of the Travis Peak range from 62 to approximately 115 gpd/ft^2; coefficients of permeability for the Paluxy Formation range from 36 to 47 gpd/ft^2.

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* gallons per day/per foot

The Paluxy Formation is very variable in thickness and consists of fine-grained sand, sandy shale, shale, sand lenses, and anhydrite. The coefficients of transmissibility are variable in the area due to changes in thickness and lithologic character in the direction of dip. Where measured in Dallas and Tarrant Counties, the coefficients ranged from 3,000 to 5,700 gpd/ft and averaged 4,400 gpd/ft.

Woodbine Aquifer

The Woodbine aquifer crops out in the upper part of the basin from Denton and Tarrant Counties to Kaufman County. The sediments of the Woodbine aquifer consist of lenticular, cross-bedded, loose to slightly consolidated, fine-grained sands and sandstones interbedded with laminated clay, gypsiferous clay, lignite, and silt. The sands make up about 50 percent of the thickness of the Woodbine Formation. Yields from the large-capacity wells average about 130 gallons per minute but some reach 600 gallons per minute (Texas Water Development Board, June, 1966).

Reported coefficients of transmissibility range from 300 gpd/ft to 12,500 gpd/ft over the area while the coefficients of permeability range from 1 gpd/ft^2 to 48 gpd/ft^2. The fine sand, the pronounced lenticularity of the beds, and intricate interfingering of clay and sand are factors which contribute to the low and variable coefficients of transmissibility of the aquifer.

Region II

The Carrizo Formation and Wilcox Group, and the Sparta Formation are the primary aquifers in Region II. The Queen City Formation is the only secondary aquifer. Other aquifers that supply small amounts of water include the Nacatoch Formation of the Navarro Group, Cook Mountain Formation, Yegua Formation, Jackson Group and the Alluvium.

Carrizo-Wilcox Aquifer

The aquifer occurs in the central part of the Trinity River Basin from Freestone and Henderson Counties south through Madison and Houston Counties.

The interlayered sand, silt, and clay of the Wilcox Group and the Carrizo Formation are in places hydraulically

connected and the two units are, therefore, collectively referred to as the Carrizo-Wilcox aquifer. The water table gradient is estimated to be up to 10 feet per mile.

The Carrizo sand has coefficients of transmissibility of approximately 25,000 gpd/ft with coefficients of permeability in the order of 350 gpd/ft^2. The Wilcox Formation has very variable coefficients of transmissibility resulting from the variable composition of the strata. However, due to its considerable thickness a coefficient of transmissibility of 20,000 gpd/ft can be assumed as an average figure with a coefficient of permeability slightly less than 350 gpd/ft^2 (Peckham et al., 1963). The coefficients indicate that groundwater can move very freely through the strata.

Sparta Aquifer

The Sparta crops out in the southern half of Region II in Madison and Houston Counties. The upper part of the aquifer consists of interbedded sand and clay whereas the lower part consists of massive, unconsolidated sand with minor amounts of shale. The sand makes up approximately 60 to 70 volume percent of the Sparta.

The Sparta aquifer has relatively high coefficients of transmissibility, ranging from 20,000 to 40,000 gpd/ft. The coefficient of permeability for this aquifer is estimated to be between 100 and 200 gpd/ft^2.

Queen City Aquifer

Outcrops of the Queen City Formation extend from an area south of Athens in Henderson County along the eastern boundary of the basin through Anderson County, and then extend to the southwest across northern Leon County. The sediments of the Queen City are heterogenous in character consisting chiefly of crossbedded, medium to very fine-grained quartz sands which are massive, thin-bedded, and interlayered with lenses of shale and sandy shale. The shale and sandy shale lenses interfinger with the sands, and gradiations from sand to shale occur both laterally and vertically.

The average water level gradient is approximately 5 feet per mile.

The Queen City Formation has relatively low coefficients of transmissibility, approximately 10,000 gpd/ft,

attributed to the heterogenous character of the sediments and the lenticular nature of the beds. It is estimated that a coefficient of permeability of 50 gpd/ft^2 is representative for the aquifer.

Region III

The primary aquifer of Region III consists of seven geologic units of Miocene, Pliocene, and Pleistocene age collectively referred to as the Gulf Coast aquifer. From oldest to youngest, they are the Catahoula Sandstone, Lagarto Clay, Goliad Sand, Willis Sand, Lissie Formation, and the Beaumont Clay. Due to difficulties in differentiating the formations in the subsurface groundwater geologists commonly group those geologic hydraulically connected units into three hydrologic units. These three units are: (1) the Catahoula Sandstone, Oakville Sandstone, and Lagarto Clay; (2) the Goliad Sand, Willis Sand, and Lissie Formation; and (3) the Beaumont Clay.

The geological units, their ages, and the hydrologic equivalents are listed in Table 2.

No aquifers are classified as secondary in Region III. Other aquifers that yield small quantities of water locally include the Jackson Group and Yegua Formation. These units crop out in the northern part of the region. The Alluvium is a minor aquifer in much of the region.

Gulf Coast Aquifer

The Gulf Coast aquifer extends from Walker and Trinity Counties south to the Gulf of Mexico. It contains interbedded sands and clays. Approximately 40 percent of the aquifer consists of water bearing sands.

The Catahoula Sandstone, Jasper aquifer, and Burkeville aquiclude crop out in an extensive area in the northern part of the region. Of these units, the Jasper aquifer is by far the principal one. The Evangeline and lower part of the Chicot aquifer overlay these units and crop out across the central part of the area. Of these, the Evangeline aquifer is the most highly developed. The Chicot aquifer is not important as an aquifer but is important in that it transmits water to the Evangeline. The Beaumont Clay is principally a poorly bedded calcareous clay containing thin stringers and beds of silt and fine sand. It crops out across the southern half of

the area, thus forming essentially an impervious blanket covering the other aquifers. Collectively, the Evangeline aquifer and the lower part of the Chicot aquifer constitute the most prolific part of the Gulf Coast aquifer.

These aquifers are hydraulically connected and may be treated as a single aquifer.

Most of the water occurring in the Gulf Coast aquifer is under artesian pressure, as attested to by the numerous flowing artesian wells in the region. In general, the movement of groundwater in the aquifers is in the direction of regional dip of the formations, in this case from the outcrop toward the Gulf Coast.

Permeabilities and thicknesses of water bearing sands of the aquifers differ greatly from place to place resulting in highly variable water bearing characteristics of the Gulf Coast aquifer. In the southern part of Region III, the water in the deeper parts of the Gulf Coast aquifer becomes progressively more mineralized causing a sharp decrease in the total thickness of the fresh water sands. The coefficients of transmissibility range from a few thousands gpd/ft to more than 200,000 gpd/ft. These figures are based on average permeabilities and also the thickness of the sand beds containing water having less than 3,000 ppm dissolved solids.

DEPOSITS OF OIL AND GAS, ROCKS AND MINERALS

Deposits of oil and gas, rocks and minerals are abundant in the immediate vicinity of the Trinity River and its valley. Many of them are of commercial importance and are exploited at the present time providing a substantial income for portions of the population in the area. Others are of commercial potential and might be utilized in the future.

Oil and gas deposits dominate in the Regions II and III whereas worked sand and gravel deposits occur most frequently in Region I. Mined lignite and sandstone are confined to the northern part of Region II, sulfur to the southern part of Region III.

Oil and Gas - Region I

In Region I, most of the oil fields are located in the vicinity of the Trinity River Valley, Tennessee Colony

area, with comparatively few oil and gas wells occurring in the immediate floodplain of the Trinity River (Figure 7 and Table 3). Investigation has shown that the brines produced in the oil fields are discharged into unlined pits or onto the ground with surface runoff and seepage to lower lying areas and creeks, some of which drain directly into the Trinity River. The special problems of oil field pollution are discussed in detail on page 123 of this report.

Oil and Gas - Region II

Most of the oil fields in this region (Figure 8 and Table 4) are genetically related to the faults which cross the area and which belong to the Elkhart fault system. Others are associated with the salt domes which intruded their overlying sedimentary cover. Discharge and spillage of oil and brine, and also gas torching are widely practiced resulting in possible pollution of surface waters and air.

Oil and Gas - Region III

Oil and gas fields are numerous in the lower part of the Trinity River Basin (Figure 9 and Table 5).

The practice of maintaining unlined sludge pits is generally followed. In many areas, the brine is discharged directly onto the ground causing tree kills over large areas and occasionally the formation of salt flats.

Gas torching is also practiced at several sites which might contribute to air pollution because of the possible sulfur content of the gas.

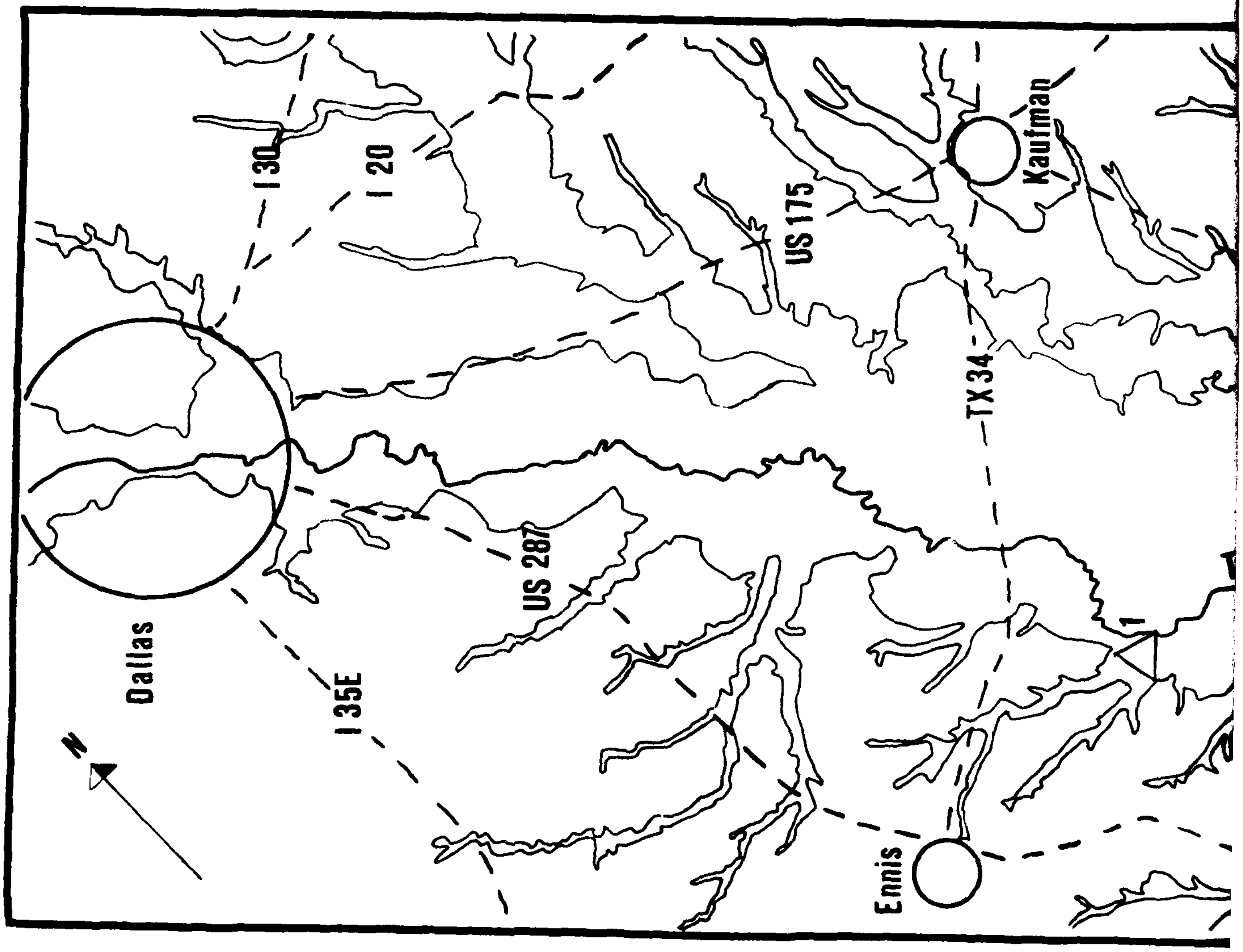
Sand and Gravel - Region I

This region contains numerous gravel and sand deposits many of which have been exploited in the past. Several are presently in production and supply mainly the Dallas area (Figure 10 and Table 6).

In the Dallas-Fort Worth area most of the sand deposits are not worked at the present time.

Region I - Oil and Gas

Number	Name
1	North Hopewell
2	Flag Lake


N
Dallas
I 30
I 20
US 175
Kaufman
TX 34
US 287
I 35E
Ennis
1

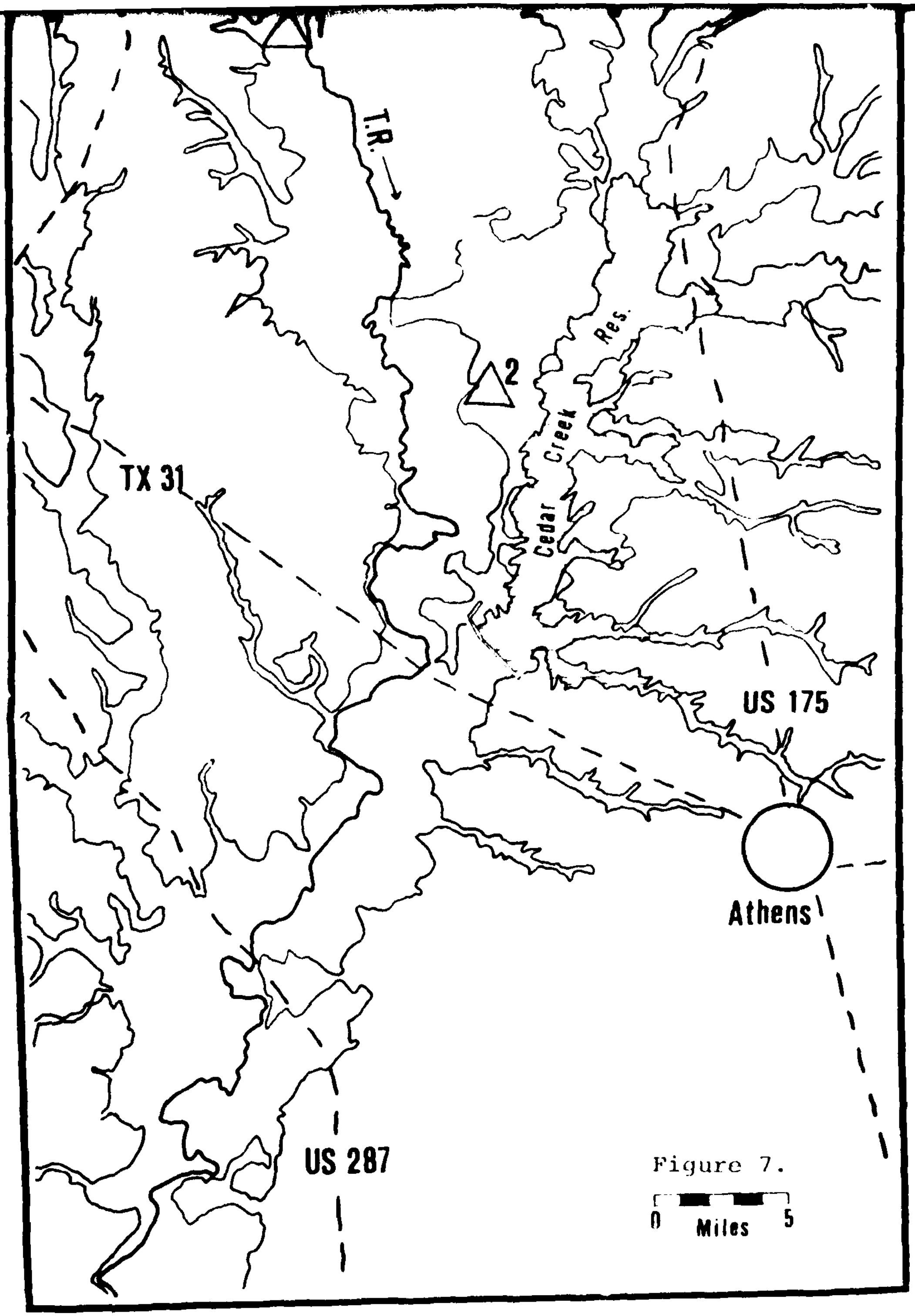


Figure 7.

Table 3. Oil and Gas Fields in Region I

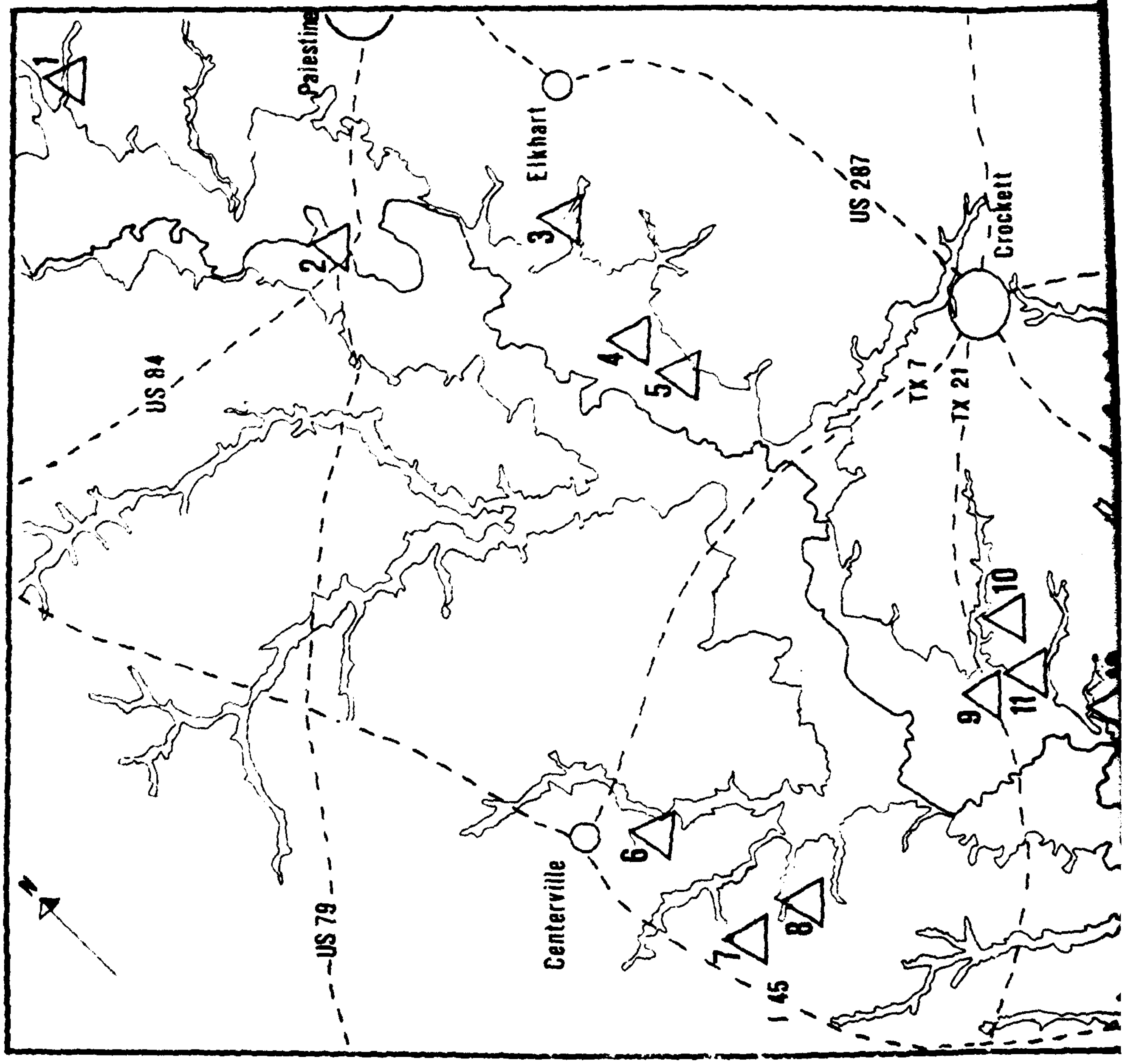
Name of Field	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
Flag Lake	West of the Cedar Creek Reservoir, off 274	J&B Swabbing Co.	X (1 well)		Oil surface runoff; dead trees. The area is very close to the Trinity River, and effects on the river water may be substantial	
North Hopewell	Along FM 1182, north of Hopewell church.	Big Deal Oil Co. Longby Oil Co Sange ?	X X X		Oil pools are common. Mostly production of brine which is probably discharged into the Trinity River.	Wells are all small, many of them are not in operation at the present time.
South Kerens		Texaco Inc. and Edson Co.	X		Present pollution by unlined sludge pits.	
Reka		Colorado Oil & Gas Corporation	X		Sul.	
South of Streetman Freestone County		Getty Oil Co.	X		Sulfur is recovered from the gas.	Smackover Fm., depth 11,000 - 13,000 feet.
W. Stewards Mill			X			
Stewards Mill		Basin Operating Co.		/X		
Bethel		Texaco Inc.	X (in south part of the field, 1957-present.		Sludge pits and pollution noticed. Brines are supposedly pumped into disposal wells.	Salt dome structure trap in 5,500-8,700 feet depth, new drilling of well.
Cayuga		Texaco Inc. and Getty Oil Co.; Getty is operator (southern part of field). American Petrofina Co. of Texas.	X		Large extent of present pollution by oil and brines. Many unlined sludge pits.	Reserves for approximately 10 years.

Table 3. Continued

Name of Field	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
Stephens Lake				/X		
South Malakoff Tri-City						

Region II - Oil and Gas

Number	Name
1	Prairie Lake
2	Long Lake
3	Elkhart
4	Navarro Crossing
5	Ralph Spencer
6	Pleasant Ridge
7	Leona
8	OSR
9	Mapleton
10	Fort Trinity Oil and Gas
11	(Southeast of Mapleton)
12	Fort Trinidad
13	Kittrel (Trinity)


Palestine
1
2
3
4
5
6
7
8
9
10
11
Elkhart
US 287
Crockett
US 84
TX 7
TX 21
US 79
Centerville
I 45
N

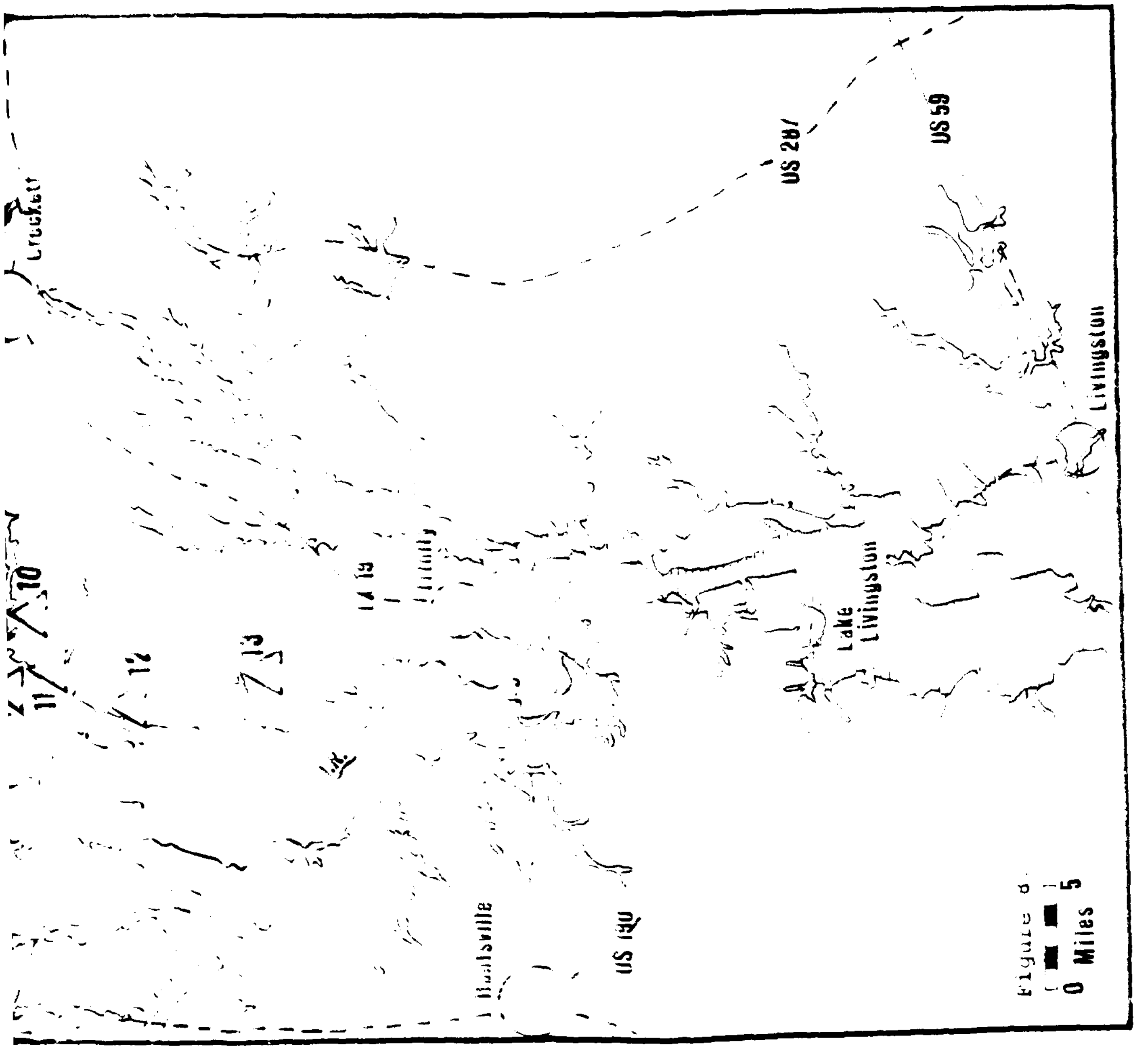

Crockett
US 287
US 59
Livingston
Lake Livingston
Trinity
10
11
12
13
14
15
Huntsville
US 190
0 Miles 5

Figure 8

Table 4. Oil and Gas Fields in Region II

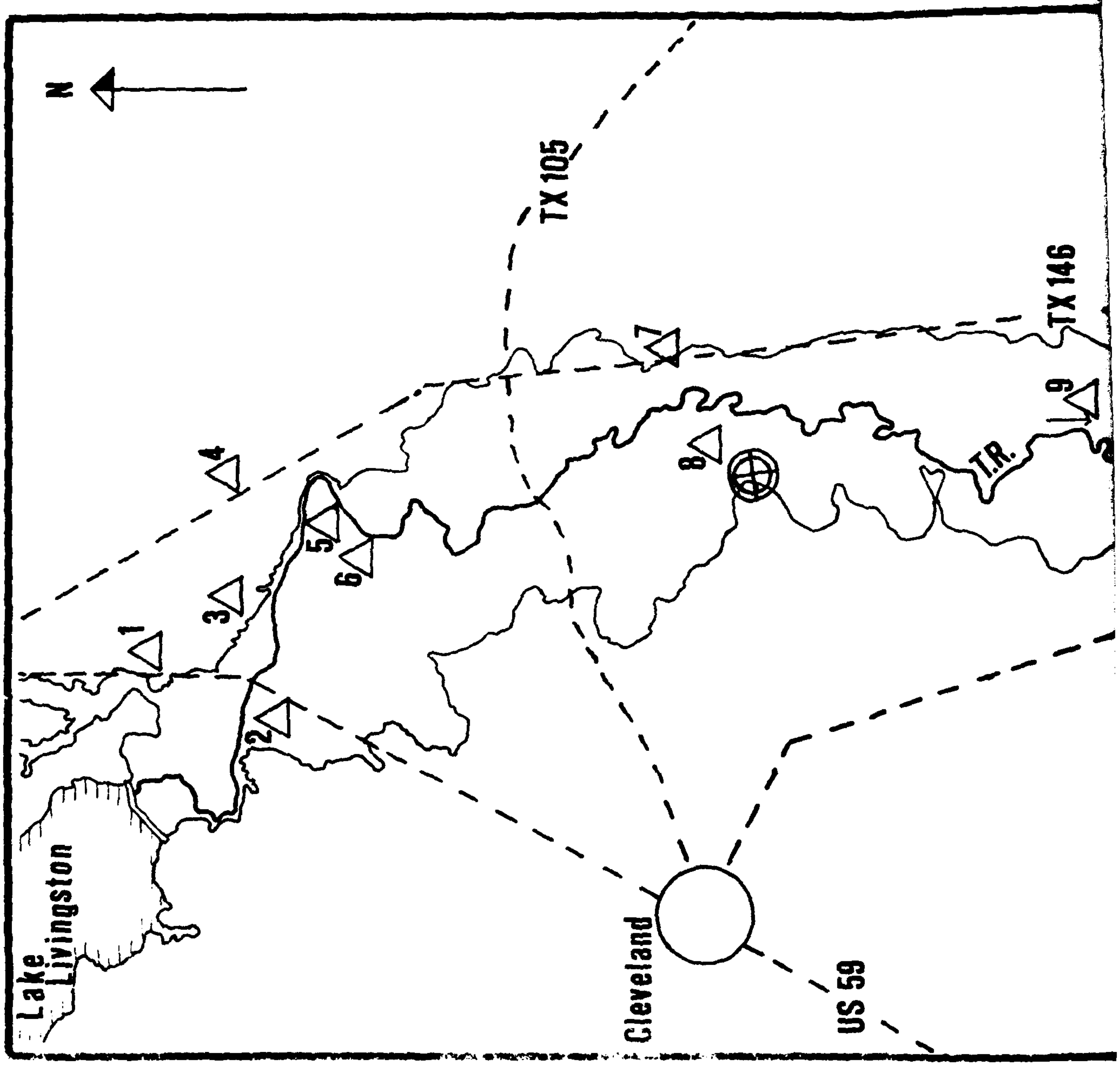
Name of Field	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
Kittrel (Trinity)	Southwest of village of Pleasant Grove and east of Dillard Creek	Humble Oil & Refining Co.	X		Unlined sludge pits.	Apparently no brine production. Salt dome size about 1 mi^2. Top of salts is at a depth of 3000 ft. Wells are 1600-12000 feet deep.
		Trimac Oil Co.	X(also 1 gas well)			
		Sun Oil Co.	X			
		Boone Bros.	X			
Fort Trinidad Oil and Gas Field	East of the Trinidad field, northwest of the village of Weldon and northeast of Madison.	Diamond M Drilling Co.	X (gas)		Unlined sludge pits. Minor spills with direct runoff into the river. (?)	Torching of gas practiced.
		Union Oil of California	X (gas)			
		Pure Oil Co., et.al.	X (plant)			
	Southeast of the village of Mapleton	The Moran Corp.	X			
		Glenrose Corp.	X			
Mapleton	Southwest of the village of Mapleton	Samedan Oil Corp.	X (tanks & wells)			Oil pits around the tanks.
		Petroleum Corp. of Texas	X			
Fort Trinidad Oil & Gas	On the north side of the Trinity River, close to FM 2915	Pure Oil Co., et.al.	X			Oil is discharged onto the ground.
OSR Oil Field	FM 977, north side, southwest of the village of Middleton.	?, Bert Fields Jr., Operator		X		
		Perryman Co.		X		
Leona	East of the village of Leona on FM 977	Samedan Assoc., Inc.	X			Gasoline plant.

Table 4 - Continued

[illegible]	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
Pleasant Ridge	Northeast cemetery the village of Pleasant Ridge, along FM 1119.			X		
Ralph Spencer	West of the village of Grapeland.	Mobil Oil Corp.	X			
Navarro Crossing	West of the village of Grapeland.	Leland Fikes Oil Co.	X		Some overflow exists from one well. A pit is not present. The oil and brine discharge flows directly into an intermittant creek with many dead trees in downstream direction.	One well.
		Humble Oil & Refining Co.		X		
		Lone Star Producing Co.	X			
		Sun Oil Co.		X		
		Carter-Gragg Oil Co.		X		
Elkhart	Southwest of the town of Elkhart	?		X		
Long Lake		Getty Oil Co.	X		Discharge of oil onto the ground; full, unlined pits and dead trees in neighborhood. Overflow of oil pit causes extensive spill. Unlined pits, also many dead trees exist. Pits are located below the storage tanks and are unlined. Large oil spills causing alleys of dead trees.	Apparently gas torching is practiced from time to time. Area is subject to active erosion. Northeast of Lost Lake, 2 storage tanks.
		Texaco Inc.	X			
		Tenneco Oil Co.	X			
		Hunt Oil Co.	X			
		Mobil Oil Corp.	X			
		Stroube & Stroube Oil Co.	X			
		Getty Oil Co.	X			
		Sinclair	X			
Prairie Lake	Southwest of Tennessee Colony	Continental Oil Co.	X		None evident	

Region III - Oil and Gas

Number	Name
1	Morgan Creek
2	West of Urbana
3	Copeland Creek
4	Schwab Creek/Livingston
5	New Ace
6	George Taylor Lake
7	North Moss Hill & Northwest Moss Hill
8	Davis Hill
9	Hardin
10	Martha
11	South Dayton
12	South Liberty
13	Eminence, East Side
14	Eminence


N
Lake Livingston
Cleveland
US 59
TX 105
TX 146
T.R.
1
2
3
4
5
6
7
8
9

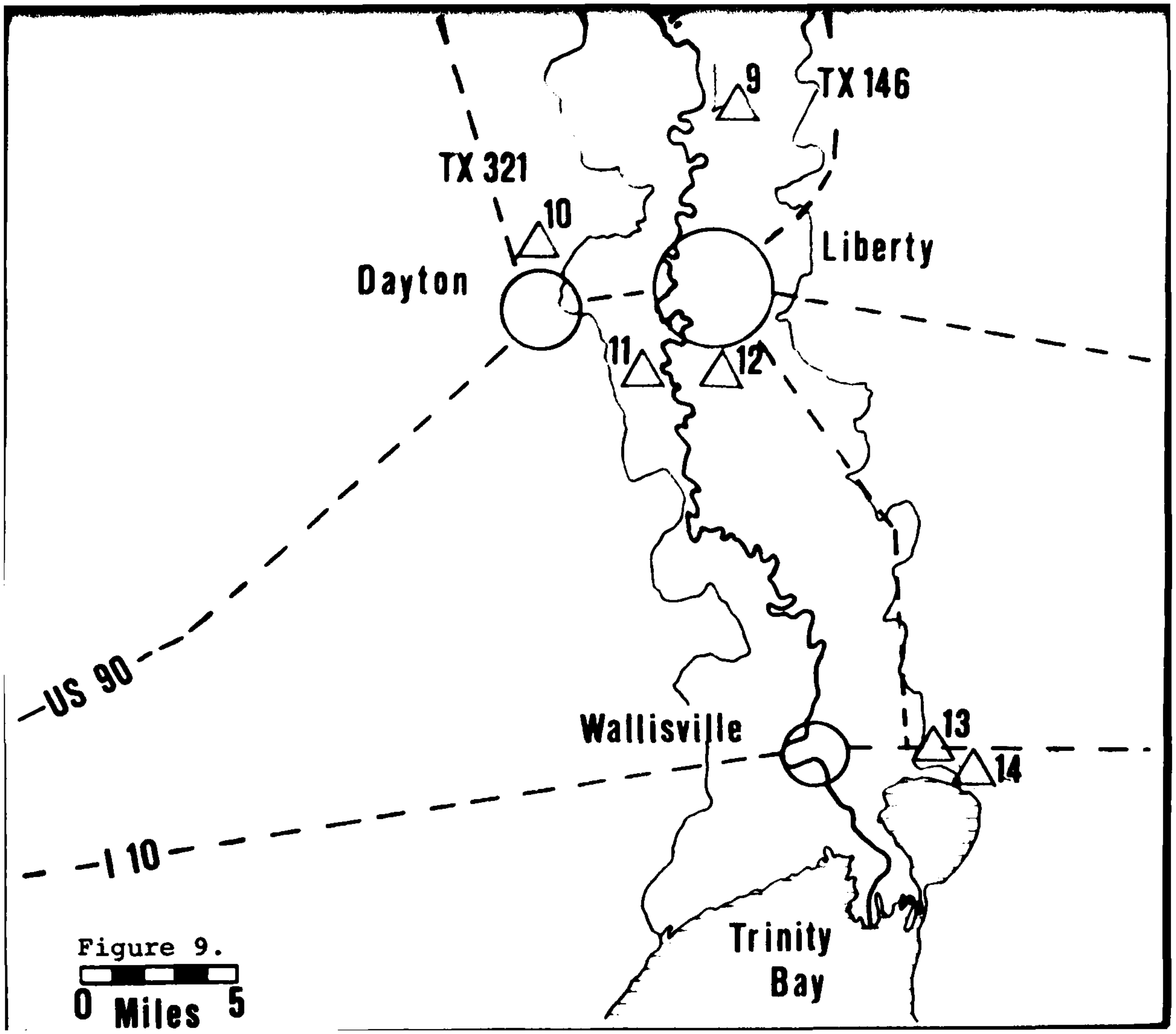


Figure 9.

TX 146
9
TX 321
10
Liberty
Dayton
11
12
US 90
Wallisville
13
14
I 10
Trinity
Bay
0 Miles 5

Table 5. Oil and Gas Fields in Region III

Name of Field	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
Eminence, East Side	West of FM 563, north of town of Anahuac, north of Turtle Bayou	Sun Oil Co.	(storage only)		Unlined, elevated, sludge pit containing much oil; approximately 10 x 20m size. In the lowland below the pit occurs a salt and oil flat covering approximately 100 x 100m.	Seepage to the lowland from the pit is highly probable.
Eminence	Along the road to the beach of Lake Anahuac.	Amoco Production Co.	X (also separation tanks)		Tanks are surrounded by an empty retaining sludge pit. Oil and brine can be found in adjacent pools.	Very serious pollution problem.
Moss Bluff	Liberty Co., north of town of Eminence		X		Salt water discharged into the Trinity River. High oil, sulfur demand in river water for sulfur mining.	Oil, sulfur.
South Liberty	South of the town of Liberty	Cities Service Oil Co. Traders Oil Co. Texaco Inc. Gulf Oil Co. Colorado John W. Mecham Lenoir M. Josey, *et al.*	X X X X X X X		An excessive pollution by brine and oil exists, both of which are discharged onto the ground and flow to low-lying areas; swampy, with dead trees. Some wells (Texaco, Inc.) are situated right on the river bank.	Production is lower than in former times. One new well being drilled.
South Dayton	Southwest of the town of Liberty; west of the Trinity River.	Texaco Inc. Lenoir M. Josey Humble Oil & Refining Co.	X X X		Unlined sludge pits leak causing the formation of oil slumps. Many surface pits noted. Pollution is serious.	Surface waters might be contaminated and pose a possible problem.

Table [illegible]. Continued

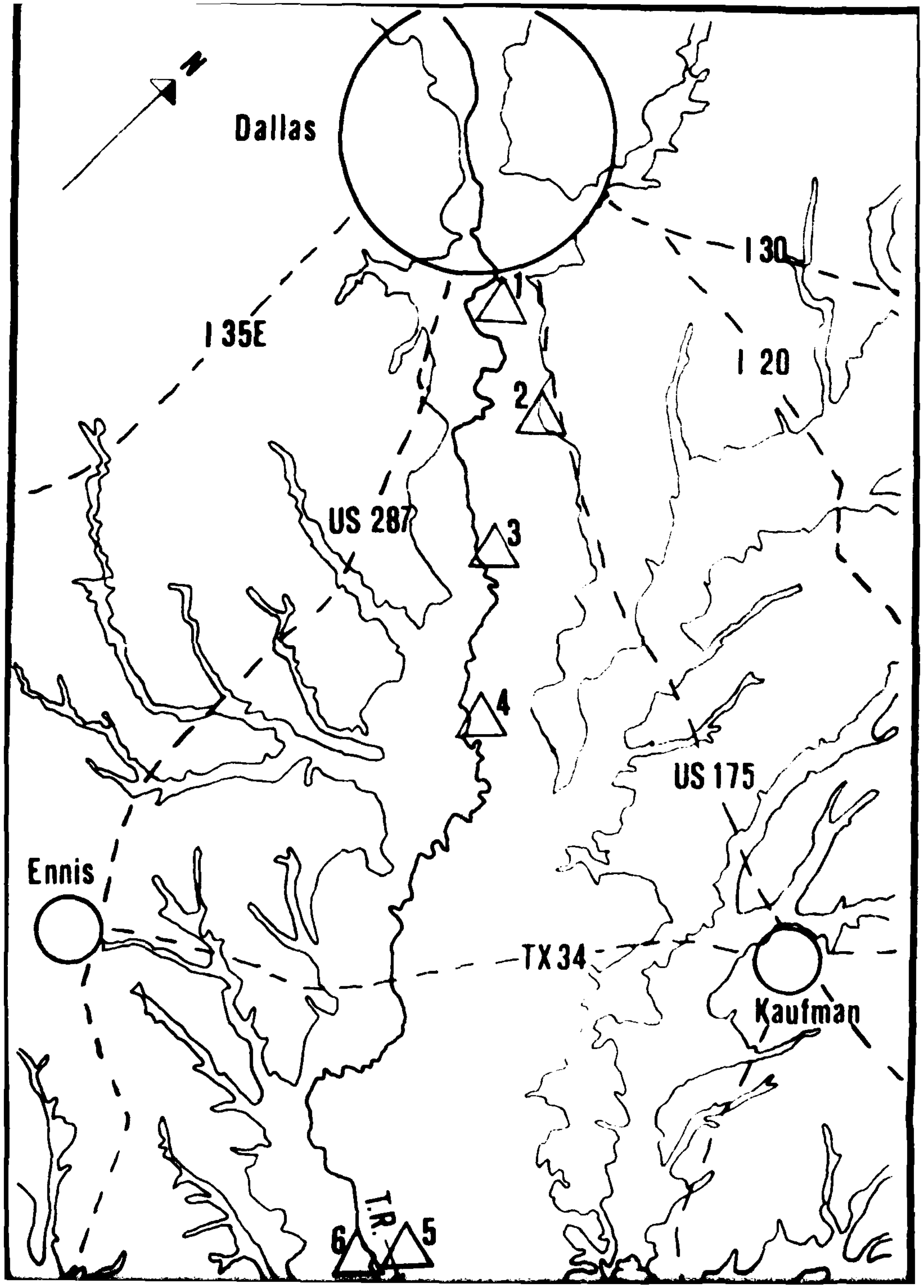
Name of Field	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
South Dayton	Along FM 1409	General Oil Co.	X		Sludge pits show apparent seepage.	Surface water contamination.
Martha	North of the town of Dayton	?		X		Pits are oil filled.
Hardin	West of the town of Hardin	Mobil Oil Corp. Seco Production Co. Operator, W. Paul Nelson	X	 X X	Oil-filled pond.	Drill cat. ?
Davis Hill	Near Davis Hill	?		X	?	
North Moss Hill & Northwest Moss Hill	Along FM 146	Texas Gas Exploration Co.	X			Gas torching is practiced.
George Taylor Lake	West side of the lake.	Texaco Inc.	X			Gas torching is practiced.
Schwab City/ Livingston	West of town of Schwab City	Humble Oil & Refining Co. Tenneco Oil Co. Sun Oil Co. Shell Oil Co.	X ? ? ?		Pollution of the creek water. Gas torching (Tenneco) and some oil overflow (Sun Oil) were observed. Oil spillage causes the dead forest parts.	Many gas wells.
New Ace	East of village of Goodrich, west of the Trinity River.	?	X			Check from river is advisable.

Table Continued

Name of Field	Location	Producing Company	In/Apparently In Production	Not/Apparently Not In Production	Geological Hazards	Remarks
West of Urbana	**West of the town of Urbana**	Amoco Production Co.	X (gas well)			
Copeland Creek	Southeast of the town of Goodrich	?	X (gas?)		A small salt flat exists which drains into the adjacent lake, the Black Branch Creek and then into the Trinity River.	Check creek water salinity.
Morgan Creek	Northeast of the town of Goodrich	Shell Pipeline Corp.	X			Possibly only storage facilities

Region I - Sand and Gravel

Number	Location	Producing Company
1	South of Post Oak Road, South Dallas	?
2	East of city of Dallas, Southside Waste Water Treatment Plant	?
3	Southwest of Malloy bridge over Trinity River, Malloy Bridge Road, northwest of Bois d'Arc Island	Abb Sand and Gravel, Inc.
4	Bois d'Arc Island, southwest of Combine, Texas	General Portland Cement and Gifford-Hill Lagow Gravel Co.
5	East of Trinity River and east of Buffalo, Texas	Lee Holsey, owner
6	South of Potters Bluff	Lee Holsey, owner (?)
7	East of Timothy, west of Trinity River	?
8	East of Trinity River, southwest of Seven Points, west of Highway 274	


N
Dallas
I 30
I 35E
I 20
1
2
US 287
3
4
US 175
Ennis
TX 34
Kaufman
T.R.
6
5

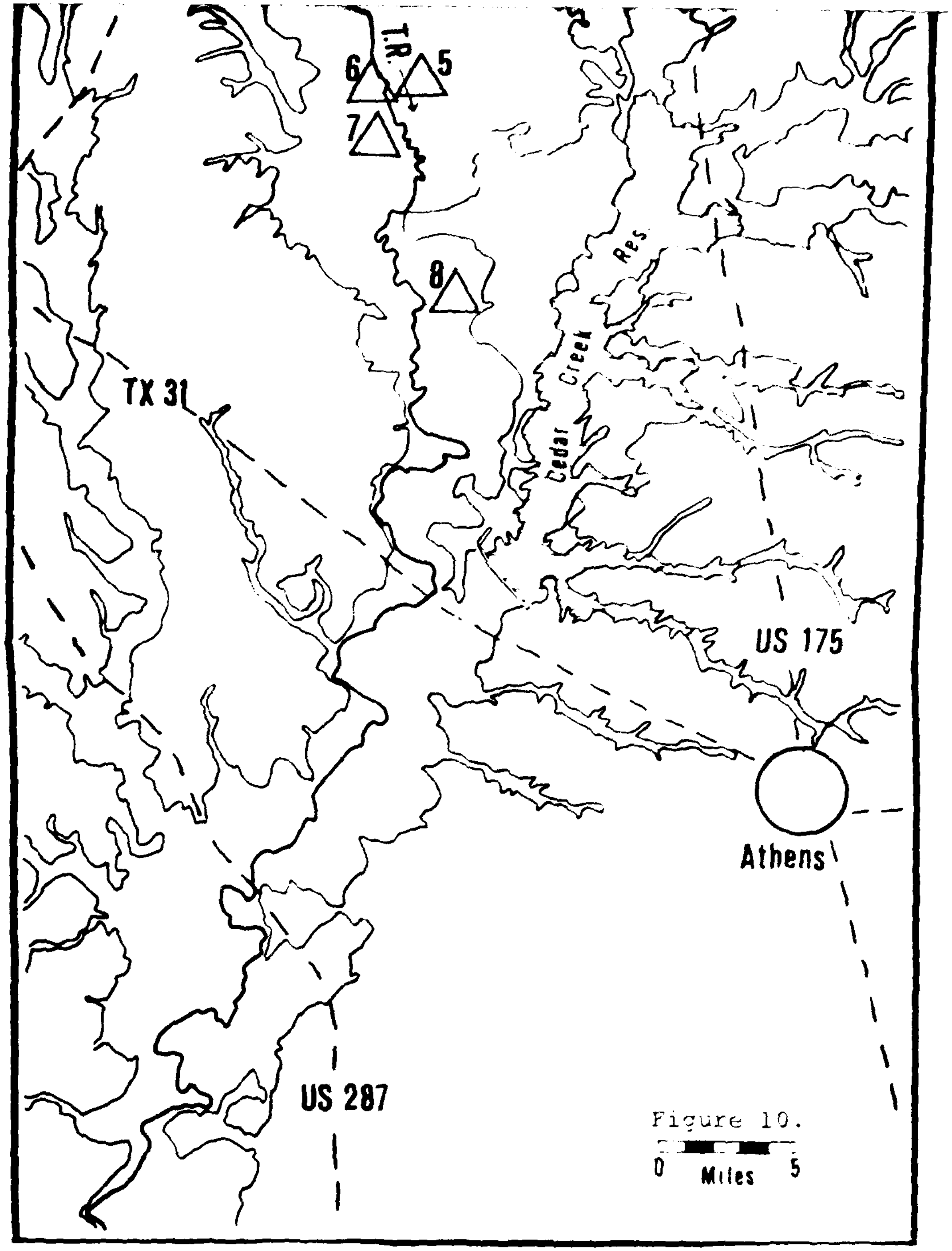
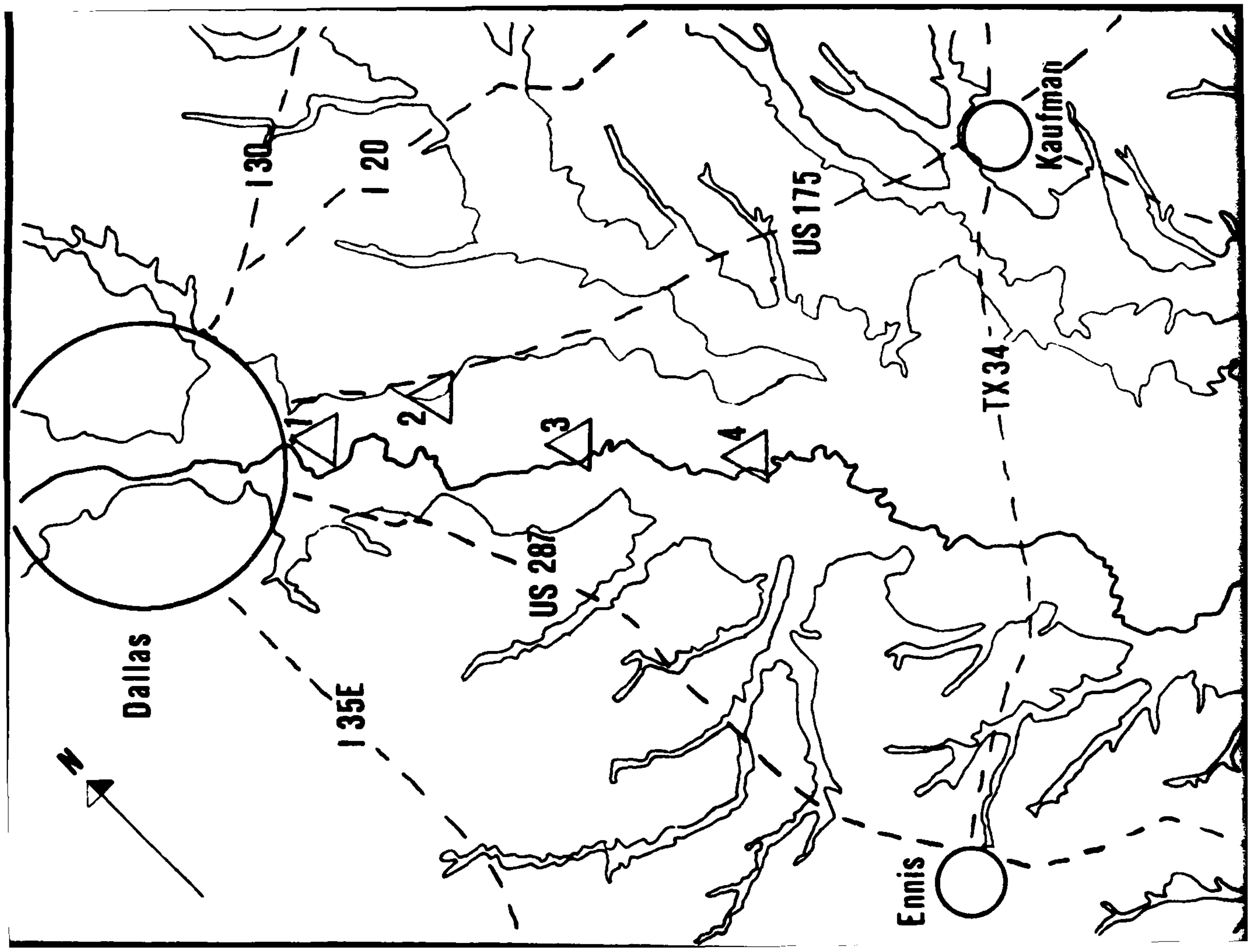


Figure 10.


N
Dallas
I 30
I 20
US 175
Kaufman
I 35E
US 287
TX 34
Ennis
1
2
3
4

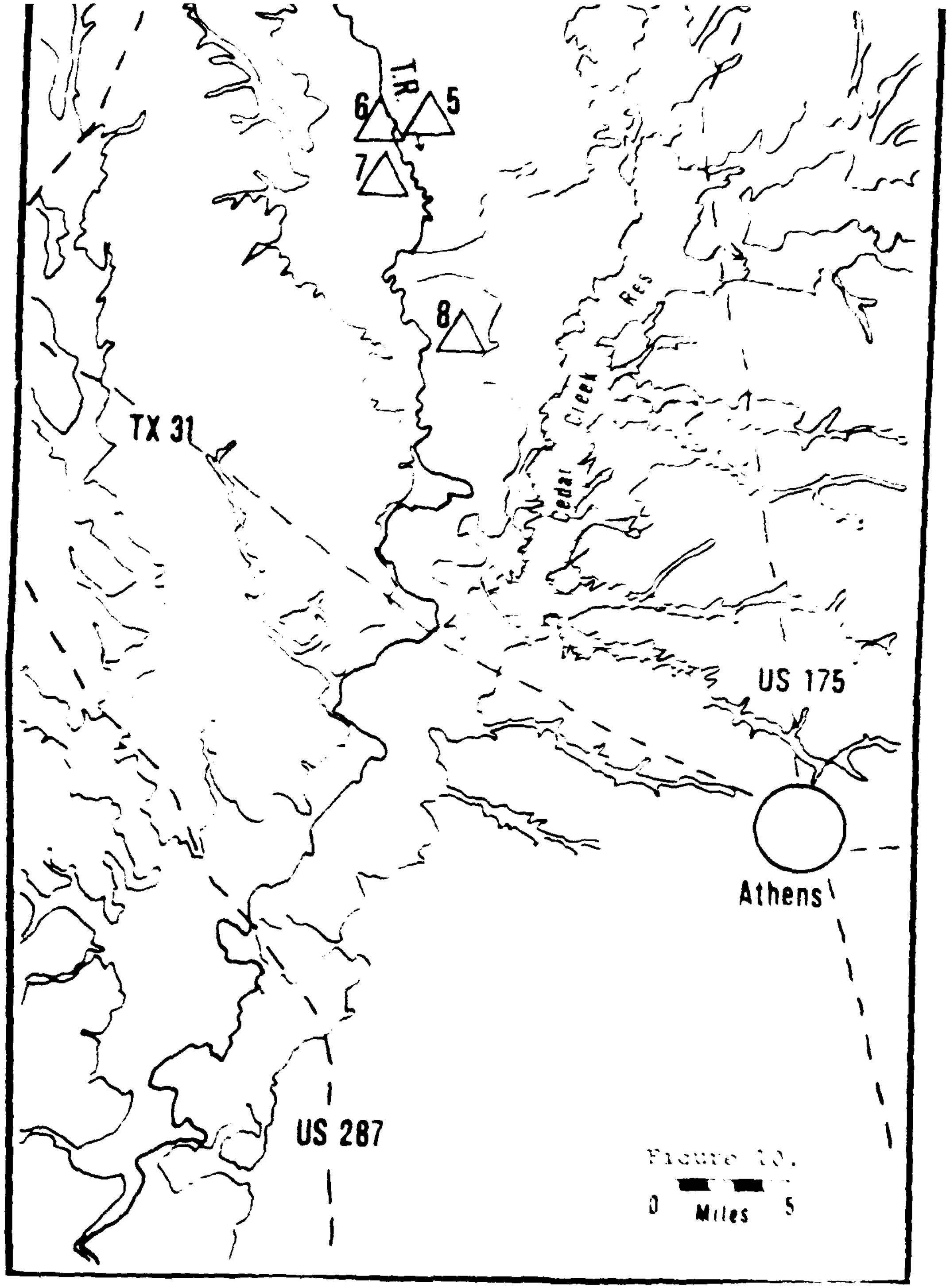


Figure 10.

Table 6. Sand and Gravel Deposits in Area I

Location	Producing Company	Sand	Gravel	In Production	Abandoned	Geological Problems	Usage
East of Trinity River, southwest of Seven Points, west of Highway 24	James Gravel pit	X	X		X		Fishing hole.
East of Trinity River and east of Buffalo	**Lee Holsey, owner**	X	X	X		The wash water is apparently not discharged into the Trinity River, which otherwise could result in silt pollution.	Road material.
South of Porters Bluff	**L. Holsey (?)**	X	X	X (limited)			Stockpile which is occasionally used.
East of Timothy, west of Trinity River.	**unknown Mrs. Weaver, owner Mr. Henderson, operator**	X	X	X (limited)	X		
Bois d'Arc Island, southwest of community of Combine.	General Portland Cement Co., Seagoville plant: also Gifford-Hill and Lagow Gravel Co.	X X X	X X X	X X X		The wash water is pumped out of the strip mine field into an apparently self-contained washing water circuit.	
Southwest of Malloy bridge over Trinity River, Malloy bridge road, northwest of Bois d'Arc Island	Abb Sand & Gravel Inc.	X	X	X			
East of city of Dallas, Southside Waste Water Treatment Plant	?		X	X			
South of Post Oak Road, South Dallas	?	X	X	X			

The most active sand and gravel production is centered around the area of Bois d'Arc Island in the alluvial plain about six miles southeast of Dallas. Some pits are as close as 1/5 of a mile to the levee of the river.

The washing water circuits are apparently self-contained; the pit water is pumped, used for the gravel wash, and discharged into storage and sedimentation pools. This avoids the discharge of silt into the river and also the necessity of pumping water out of the Trinity River for the washing operations.

Sand and Gravel - Region II

Terrace gravels are presently not mined in the region. Possible reserves have not yet been determined. Some gravel was taken from pits near the new feed lot of M. Calhoun (Figure 11 and Table 7).

Sand and Gravel - Region III

Source areas for sand and gravel are primarily the old Trinity River terrace deposits which flank the present valley (Figure 12 and Table 8). Some commercial deposits occur immediately adjacent to the Trinity River (i.e., Urbana) whereas some occur further away where they would not be immediately affected by the canal construction. The deposits near Urbana were exploited in the past, and the pits are currently water-filled. A reopening during the construction phase of the canal seems to be possible.

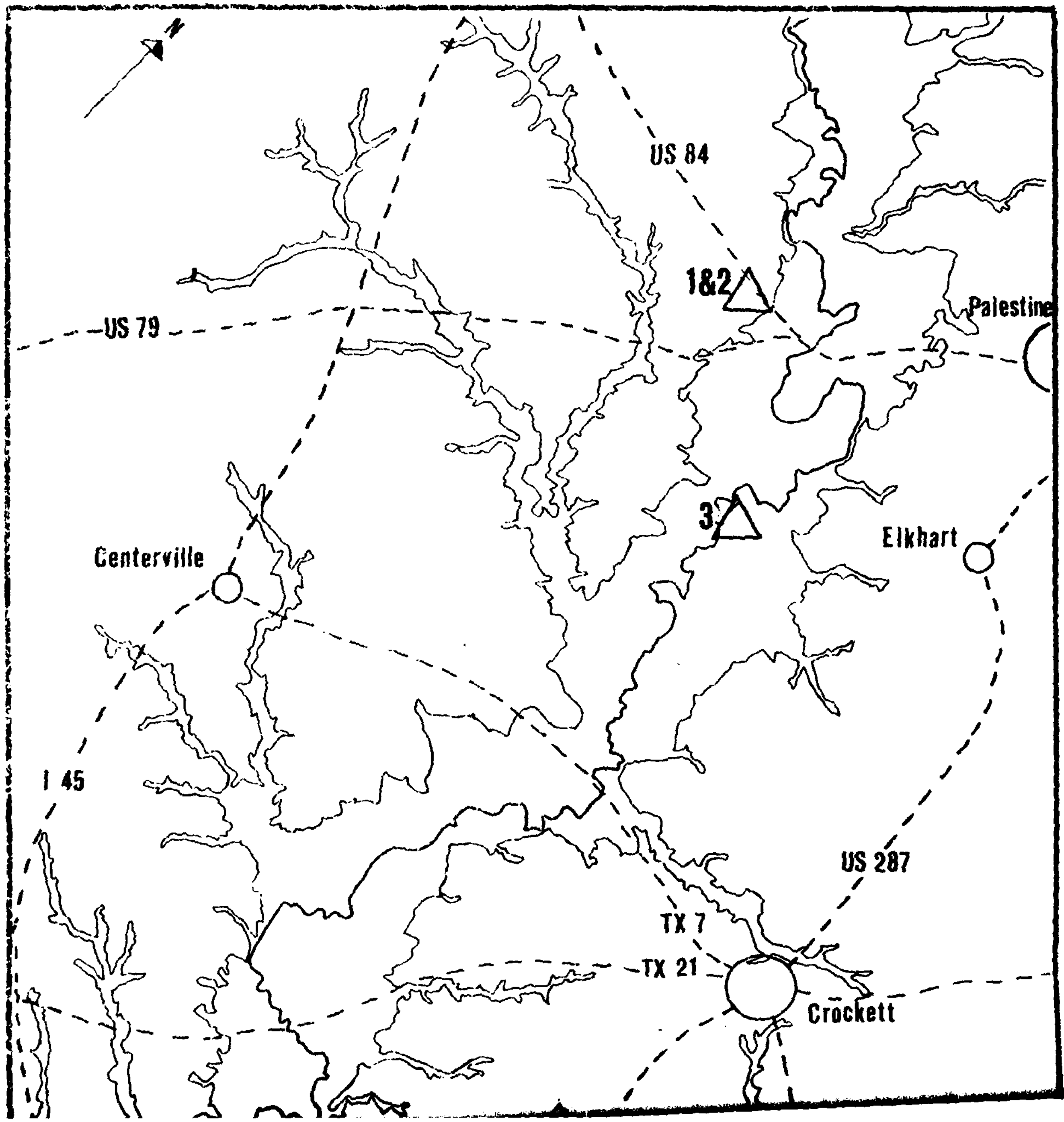
Several sand pit areas are now used as municipal dumps. This fact possibly provokes contamination of ground and surface water.

Sulfur - Region III

For two decades sulfur has been recovered by the Frasch method at the Moss Bluff salt dome in southern Liberty County. Hot water steam is pumped under high pressure into drill holes which reach the sulfur-bearing cap rock of the salt dome. The sulfur melts underground and is raised by compressed air to the surface where it is collected and pumped through a heated pipeline to river barges to be transported to the coastal area for

Region II - Sand and Gravel

Number	Location	Producing Company
1	Butler salt dome, west of Palestine	East Texas Stone Company
2	Butler salt dome, west of Palestine	Northern Propane
3	Southwest of village of Redtown, near Elkhart	Vernon Calhoun, owner


N
US 84
1&2
Palestine
US 79
3
Elkhart
Centerville
I 45
US 287
TX 7
TX 21
Crockett

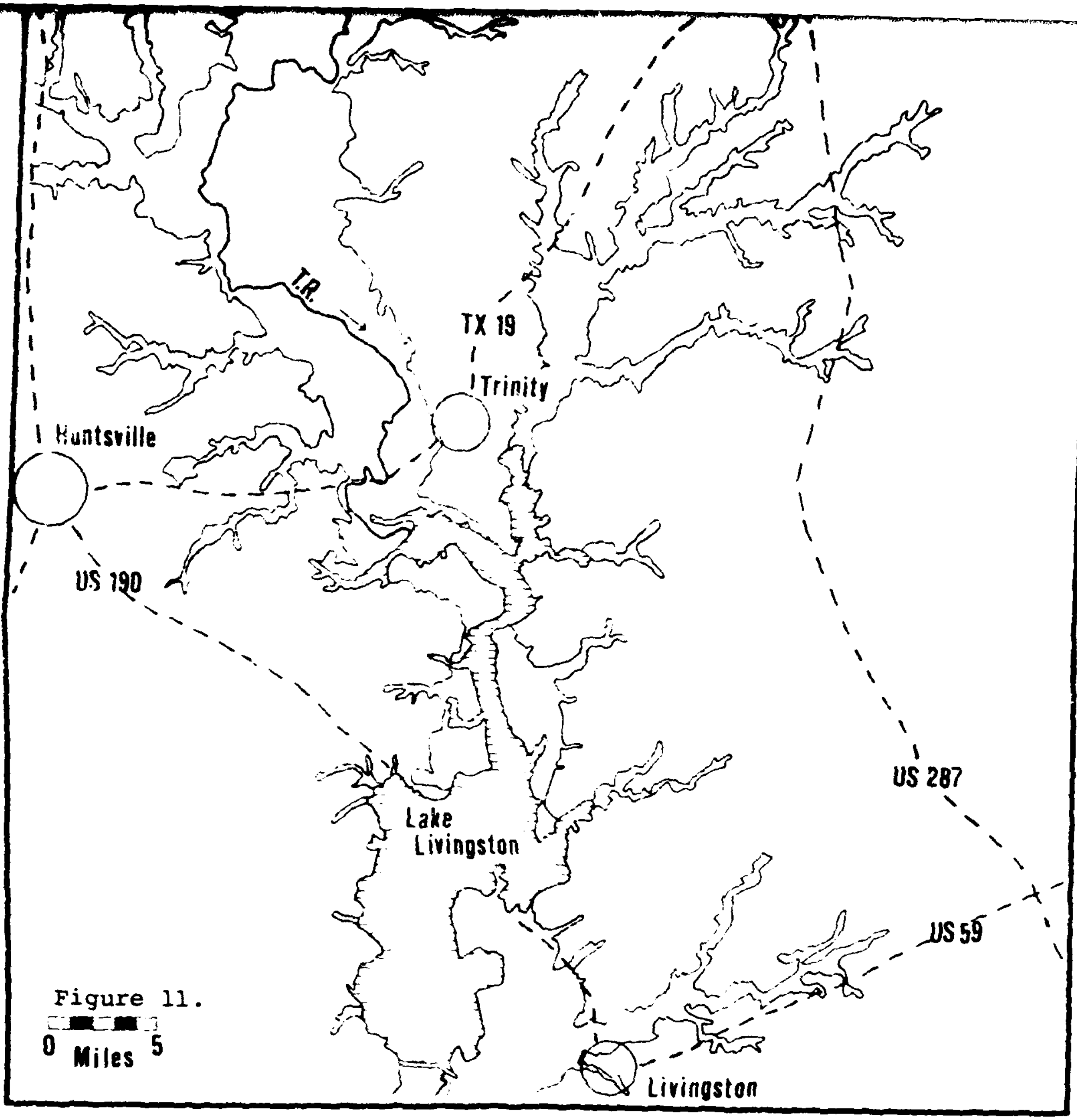

T.R.
TX 19
Trinity
Huntsville
US 190
US 287
Lake
Livingston
US 59
Livingston
0
Miles
5

Figure 11.

2

Table 7. Sand and Gravel Deposits in Area II

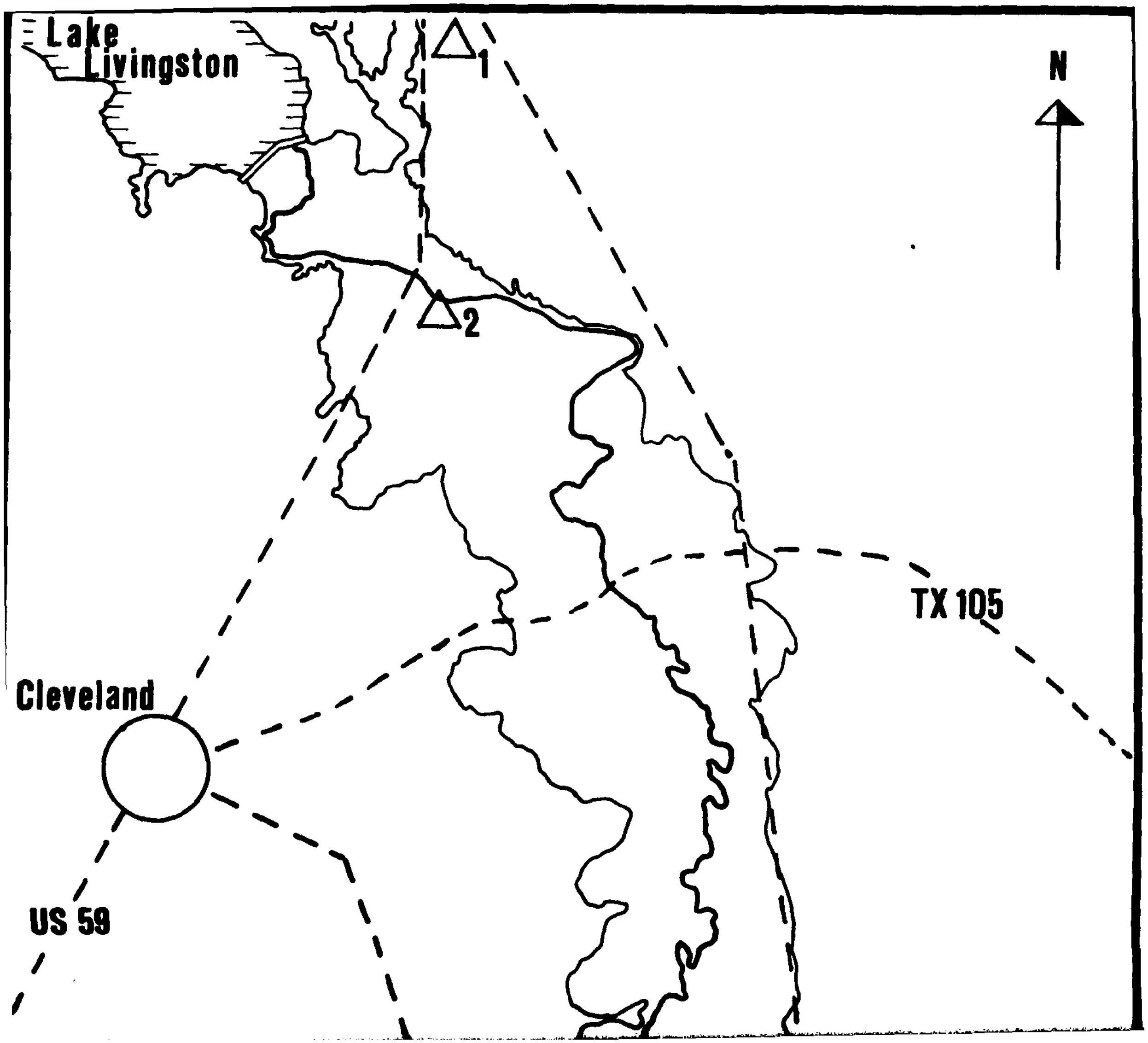
Location	Producing Company	Sand	Gravel	In Production	Abandoned	Geological Problems	Usage
Southwest of the village of Redtown near Elkhart	Vernon Calhoun, owner			[Under Construction]		The feedlot will apparently be self-contained utilizing two water wells. Each is about 140' deep located on the first terrace. Only if self-contained, problems of water pollution should not arise.	Stock lots.
Butler salt dome, west of Palestine	East Texas Stone Co.	[Sandstone]		X		Sandstone is overlain by fine grained, lignitic-pyritic sand and clay. The pyrite weathers and decomposes to give sulfuric acid. Further reactions cause sulfur blooming on the face wall and gypsum crystal formation. High acidic surface waters are produced and pumped out of the quarry into an artificial (?) lake Also, the overburden is removed and heaped up in an adjacent area which is closer to the Trinity River. Many dead trees are observed. Production of road asphalt may produce air pollution, same may be true for the crushing operation (dust).	Road material, road asphalt.

Table 7 . Continued

Location	Producing Company	Sand	Gravel	In Production	Abandoned	Geological Problems	Usage
Butler salt dome, west of Palestine	Northern Propane			[Storage of gas]		Three storage wells for butane and propane exist. Depth 1,200 feet, capacity about 12 million g/well. Salt water is pumped into one concrete lined storage pool; another one is unlined. In the winter, this salt water is pumped back into the well and the stored gas is driven out to help to satisfy the higher demands during the winter time. No runoff apparently exists but seepage is probable to lower areas adjacent to the ponds as judged by vegetation and soil appearance.	Gas storage

Region III - Sand and Gravel

Number	Location	Producing Company
1	South of town of Liberty	City of Liberty Sanitary Land Fill
2	About one mile east of Urbana, Texas	Thorstenberg (?)
3	Northeast of the Eminence church, east side of FM 563	Commercial Construction Co. Sand Pit and Trucking, V. R. Hyeton, Jr.
4	West-northwest of the Wallisville school, sandpits (Eminence)	Municipal (?)


Lake
Livingston
1
2
N
Cleveland
TX 105
US 59

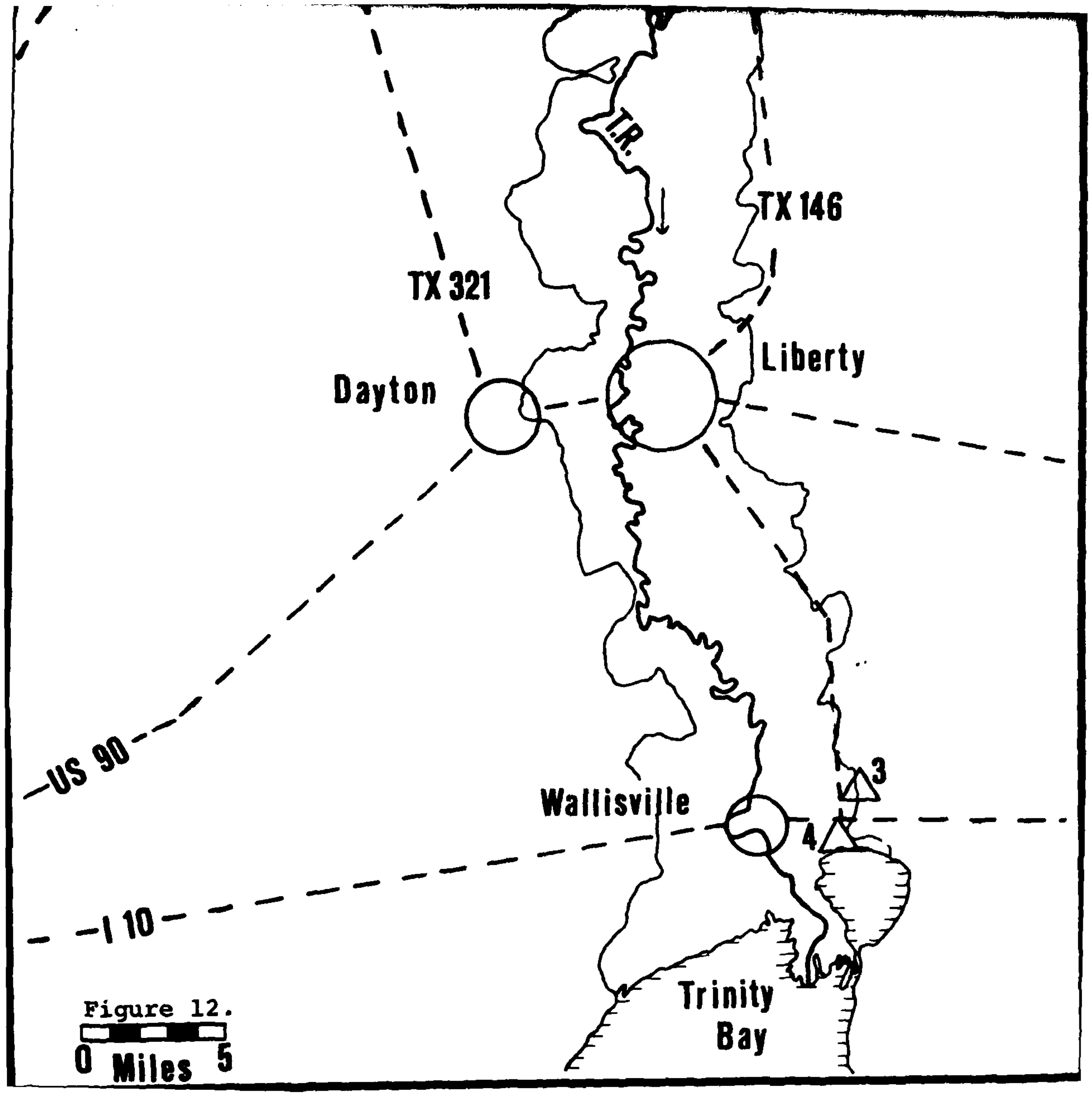

T.R.
TX 146
TX 321
Liberty
Dayton
US 90
Wallisville
3
4
I 10
Trinity Bay
0 Miles 5

Figure 12.

Table 8. Sand and Gravel Deposits in Area III

Location	Producing Company	Sand	Gravel	In Production	Abandoned	Geological Problems	Usage
West-northwest of the Wallisville school, sandpits (Eminence).	municipal?				X	Presently, it is being used as dump place. It poses a possible groundwater contamination problem for the lake.	Dump
North-northeast of the Eminence church, east side of FM 563.	Commercial Construction Co. Sand Pit and Trucking, V. R. Hyeton, Jr.	X		X		Pumping of water out of the pit has lowered the water table in the immediate vicinity so much that neighboring water wells have run dry. Pit is about 40 feet deep.	
South of the town of Liberty	City of Liberty sanitary land fill				X	Groundwater contamination is possible.	Dump
Southwest of the town of Liberty	municipal?	X			X	A groundwater contamination problem might arise	Used as stock pond.(?)
[illegible]t 1 mile east [illegible] the town of [illegible]ana.	Thorstenberg?	X			X		

further use. "Bleed" wells drain the underground productive rock mass, and the cooled-down water is pumped back to the surface. The bleed water contains many salts in solution dissolved from the cap rock. The soluble sulfide is said to be removed by treatment, and the water is then discharged into a drainage ditch which flows into a holding lake adjacent to the Trinity River. The water flow is thought to amount to about 4 million gallons per day with a salinity of 1.4 to 1.5 percent.

The Moss Bluff plant uses water that is taken out of the Trinity River at a pumping station northwest of the community of Moss Bluff where it is pumped into an irrigation canal (West Branch Devers canal) for the rice farms north and northeast of the plant. The daily supply requirements for the plant is about 5 million gallons of water which is taken out of storage ponds which have a total capacity of 750 million gallons. Seasonal variations of the silt content of the river water occur and hamper the water purification process of the plant.

Peat - Regions I and II

Peat containing bogs occur in the marshland of the flood plain of the Trinity River. Areas of potential extend from northeast of Kerens, Navarro and Henderson Counties, south to the vicinity of the Butler salt dome, Freestone County.

Peat - Region III

Several peat deposits occur in the valley of the Trinity River near the communities of Urbana and Goodrich (Shafer, 1941), and it is quite possible that others could be found. The bogs containing the peat are old meander scar bogs of the Trinity River occurring about 1/4 mile from the present river channel and adjacent to the first river terrace above the flood plain.

Although peat must be imported from out-of-state deposits, the bogs have not yet been mined. It appears that mining in small-scale operations would be commercially feasible.

Crushed Stone - Region II

A well cemented sandstone is quarried on the northern flank of the Butler salt dome, about 1/4 mile from the

Trinity River. The sandstone is crushed and used for road and constructional materials in East Texas (Figure 11).

Excessive dust emission was not observed at the time the quarry was visited. However, an extensive acid surface and pit water problem exists which is caused by the weathering of iron sulfide minerals (i.e., pyrite, FeS_2), resulting in the formation of sulfuric acid.

Salt Domes - Region II

Several salt domes with surface expression occur in Region II. The Butler dome is the closest one to the Trinity River. It is presently used only as underground storage for butane and propane gas. The facilities are operated by the Northern Propane Company.

The Palestine dome was mined for salt in the past. Salines occur as surface features on the Butler and Palestine domes. They are probably fed by small salt-water springs situated along fissures, faults, or along contacts of rocks of differing permeabilities.

Salt of the Keechi and Bethel domes is too deep to influence the chemistry of the surface water runoff.

GEOLOGICAL EFFECTS OF CHANNELIZATION AND RESERVOIR CONSTRUCTION

Creation of the Trinity River Canal and the reservoirs will result in certain geological changes within and adjacent to the Trinity River Basin. Adverse effects are mostly related to industrial activities and should be avoided by taking proper protective measures.

Immediate Effects on Industrial Operations

The alignment of the channel and the construction of lock and dam sites will affect several industrial operations which have either to be relocated or abandoned.

Region I

Pumping stations, storage tanks, sludge pits, and pipelines of many oil and gas fields will be submerged by

the Tennessee Colony reservoir. Especially affected will be the facilities of the Cayuga, Carter-Cragg, Reka, and Stewards Mill oil fields. Brine and crude oil of the sludge pits will enter immediately into the water cycle of the reservoir and river.

Sand and gravel deposit areas in the Trinity River Valley including those in the Dallas-Fort Worth area will be affected by channel alignment activities. The Julian gravel pit near Turkey Creek, Henderson County, will be submerged by the Tennessee Colony reservoir. The operation will ultimately have to be abandoned.

The sands and gravels from productive areas can be effectively utilized during the construction phase of the project. Creation of a shipping channel would probably encourage exploitation of these deposits by offering cheaper transportation costs.

Open pit mining of the clays will probably not be affected by changes in the level of the groundwater table or by channel alignment activities because most of the areas with possible clay deposits are located at some distance from the lake (Figure B-6, Stephen F. Austin University, 1972, p. B-23).

Region II

Production facilities of the Navarro Crossing, Mapleton, and Fort Trinidad oil and gas fields will be directly affected by the channelization.

Region III

Facilities of the New Ace field, the oil fields north of the town of Liberty, and the Lost Lake oil field near Wallisville will be directly affected by the construction of the canal and the creation of the Wallisville reservoir.

The reservoir will extend to the loading docks of the Texas Gulf Sulphur Company so that the salt brine which is discharged here will flow directly into the reservoir water. The part of the Trinity River at the water pumping station north of the community of Moss Bluff will be cut off from the channel to form a lake. This might endanger the necessary water supply if no protective measures are taken.

Immediate Effects on Geological Localities

Several geologic type localities and fossil localities within the basin will be disturbed by the construction activities.

Region I

The type locality of the Eagle Ford Group lies within the Trinity River Valley approximately 6 miles west of Dallas. It has yielded plesiosaur and mosasaur remains. These swimming reptiles are considered to be rare in the fossil record.

At anticipated normal water level of the Tennessee Colony reservoir some fossil localities will be inundated along the cliffs east and west of the Trinity River northeast of Kerens, Navarro County (Figure B-1, Stephen F. Austin University, p. B-5). Most of the localities are not considered to be of great significance. They are sparingly fossiliferous and contain mostly microfossils which might be collected elsewhere. The only possibly significant locality is the outcrop which yields the foraminifera *Cornuspira carinata*.

In addition, the geologic type locality of the Kerens Member, Wills Point Formation, will be submerged. The location is the cliff west of the Trinity River northeast of Kerens.

Region II

The type locality of the Onalaska member of the Catahoula Formation is located in Rocky Creek east of Onalaska, Polk County. Good exposures also occur in Kickapoo Creek of which Rocky Creek is a tributary. The geologic significance of this locality is in question because it is generally no longer recognized as a type section. The possibility also exists that the outcrop has already been inundated by Lake Livingston.

A fossil locality of the Fleming Formation known as Red Bluff located at the Trinity River in San Jacinto County has yielded vertebrate remains. The exact location of this locality is not known but mention of it as being on the James Rankin Survey has been made.

Region III

The inventory survey did not reveal any significant type localities or unique fossil localities that will be disturbed in the project area of Region III.

Long Range Geological Effects

Long range effects result from industrial activities or are effects which are related to natural geological processes.

Long Range Geological Effects on Oil Field Pollution

Oil is produced in a large number of oil fields, and brine is pumped with the oil. Ionic constituents of oil field brines are essentially sodium, chloride, and frequently sulfate. Poor oil field brine disposal practices have resulted in the drainage of these brines into the tributaries and ultimately into the Trinity River.

Region I

Extensive oil production and poor oil field brine disposal practices result in considerable pollution in the Tennessee Colony reservoir area. Available data of Osborne and Shamburger (1960) show the extent of the pollution. They conducted a study of the effects of oil field brine on water quality in the lower watershed of Chambers and Richland Creek, Freestone County, and reported a total daily brine yield of 95,300 barrels disposed of on the surface. Their conclusion was that approximately 61,500 barrels drained daily directly into the tributaries of Chambers and Richland Creek.

The brine increases the salinity of the tributaries and the reservoir water. Leifeste and Hughes (1967) found chloride concentrations in Richland Creek to be unusually greater than 1,000 ppm and at times exceeding even 7,000 ppm. They also reported the pollution of Tehuacana Creek waters by discharged oil field brines.

Presently published information appears not to be available about the amount of oil field brines produced by the other fields in the area nor information about their techniques of oil field brine disposal. It is known, however, that brine is produced in nearly all fields in the

Trinity River Basin and that the brine is frequently pumped into unlined sludge pits or directly discharged into surface water drainage (Leifeste and Hughes, 1967). Usage of disposal wells appears to be an uncommon practice.

Region II

Oil and gas production associated with the Elkhart-Jarvis-Mt. Enterprise fault system in the vicinity of the Trinity River Basin west of Elkhart, Freestone County, creates a potential pollution problem. Oil fields in the area produce large quantities of brine, and the present practice is to pump it into unlined sludge pits or to discharge it directly onto the ground or into local creeks

The creation of an oxbow lake with stagnant water adjacent to the Butler salt dome enhances the possible acid water pollution problem caused by the sandstone quarry operation. This problem can probably be overcome by proper treatment of the acidic water and the overburden dumps.

Region III

The same pollution problems exist for the oil fields in this region as discussed above. Severe problems may arise from the spillage of oil and brines in the South Liberty oil fields. Lost Lake oil field will be isolated on an island in very shallow water of the Wallisville reservoir.

The oil field brines together with the salt water discharge from the sulfur plant will eventually increase the salinity in the Wallisville reservoir.

Long Range Geological Effects on Density Stratification

The discharge of brine polluted creek waters from oil fields and salt domes into the Trinity River increases the salt content of the river water. Where the river and/or creeks discharge into a reservoir with its restricted circulation, density stratification in the reservoir basin may result. The denser creek or river waters tend to underflow the less dense lake water displacing it upwards. The lack of circulation within the lower levels of the lake water soon results in reducing chemical conditions near the bottom of the basin. The activity of

anaerobic bacteria on bottom matter soon produces large quantities of ammonia and possibly hydrogen sulfide gas, both seriously affecting the water quality, and plant and animal life. Flushing of the reservoir is a measure to correct this situation but it would produce harmful and lethal conditions downstream, e.g., large fishkills (Eley, et al., 1967).

Region I

The discharge of brine from the numerous oil fields in the Tennessee Colony area will increase the salt content in the reservoir. The various aspects of the resulting pollution problem were previously discussed in this report (p. 123), and in detail in the Tennessee Colony report (Stephen F. Austin State University, 1972).

Region II

Several oil fields occur in or near the Trinity River Basin between Tennessee Colony and Lake Livingston. Most of these fields practice poor oil field brine disposal techniques and consequently contribute brine to the river. The Butler dome has a salt flat developed on its surface and is also a possible natural contributor of salt to the river (Fisher, 1965).

Surface runoff from the Palestine salt dome during heavy rains may also contribute salt to the river water because a saline exists on the surface of the dome (Fisher, 1965) and surface runoff from the dome eventually enters the river via Town Creek.

Region III

Brine pollution from several oil fields above Wallisville will ultimately increase the salt content of Lake Wallisville. Another source of salt is the discharge water from the Texas Gulf Sulfur Company's sulfur mining operations. The discharge was found to contain about 14,700 ppm chlorides. Lake Wallisville may also eventually develop density stratification.

Long Range Geological Effects on Siltation

The higher salt content of the river and reservoir waters will increase the rate of siltation in the river and in the reservoirs because the presence of larger

quantities of salt in water causes the flocculation of the suspended clay particles and, ultimately, their sedimentation. This accelerated siltation contributes to the normal silting in the reservoir basins and in the river.

The Trinity River drainage basin will supply a large amount of suspended load into the river and into the reservoirs. Causes are natural soil conditions, climatic and seasonal fluctuations of the precipitation, and poor land management practices. The average suspended load input varies on a monthly and annual basis, and appears to fluctuate with the seasonal rainfall. The highest input occurs usually during the spring which is the rainy season and the time of most active cultivation of the land.

Channel realignment and widening causes changes in the water flow regime, i.e., increase of flow velocity and turbidity. Erosion of the unconsolidated flood plain deposits and transport capabilities are generally enhanced Silting-up occurs when the river and creek currents are slowed down upon entry into the still water of the reservoirs, and it is increased by the higher content of dissolved salts.

Region I

Data from the Rosser water sampling station (located at State Highway 34 bridge between Ennis and Rosser, approximately 45 miles upstream from the proposed Tennessee Colony dam site) reveal that over the six year period from 1954 to 1959 an average of 1,265,819 tons per year of suspended load passed the station. The net drainage area above this station covers 8,162 square miles. Data from the Romayor station (located at State Highway 105 bridge, 2 miles south of Romayor, approximately 112 miles downstream from the proposed reservoir) show that an average of 3,377,765 tons per year passed that point between 1954 and 1959 (Stout, et al., 1961). The net drainage area for this station covers 17,192 square miles. This resulted in an input of approximately 2,112,000 tons per year of suspended load between the two sampling stations. It is estimated that approximately 1,003,200 tons per year or 47.5 percent of suspended load input were contributed by the drainage area between the upstream station and the Tennessee Colony dam site. The estimated suspended load input into the reservoir for the years 1954-1959 amounts to approximately 2,269,019 tons per year.

Region II

Calculation of the amount of suspended load transported into the Trinity River between the proposed Tennessee Colony reservoir and the Romayor gauging station gives a figure of approximately 1,108,746 tons per year. Based on a drainage area calculation covering the area between Tennessee Colony reservoir, Lake Livingston, and Romayor gauging station, it is concluded that approximately 964,809 tons per year of suspended load would have been put into Lake Livingston during the years 1954 to 1959. It is believed that this figure is fairly representative of present conditions.

Region III

The net drainage area above the Wallisville reservoir is approximately 17,869 square miles. The total drainage area of the Trinity River Basin is 17,969 square miles. A total of 6,862,500 tons of sediment is discharged into the Trinity Bay annually.

The input of sediment into the river between Lake Livingston and Trinity Bay amounts to approximately 3,628,672 tons per year.

Of this amount, approximately 2,902,938 tons of total sediment annually reaches the Lake Wallisville area. These figures can serve as a guideline for further considerations.

Long Range Geological Effects on Groundwater Changes

Presently, the water table slopes toward the alluvium of the drainage basin. Channelization will probably not significantly alter this condition, but in the reservoir areas the initial effect of the impoundment on the groundwater will be the reversal of the slope of the water table adjacent to the reservoir. Impoundment may also produce recharge to the aquifers by lake water.

Region I

Noticeable effects of groundwater changes might be a reversal of the slope of the water table adjacent to the Tennessee Colony reservoir with resulting water level increases in wells, and a more uniform water level in stock ponds.

Impoundment may also produce recharge of the aquifers by lake water. The alluvium in the reservoir basin will control the rate of recharge of the aquifers assuming that the aquifers have a higher permeability than the alluvial sediments.

Silting on the bottom of the reservoir could reduce the effectiveness of the artificial recharge. It would reduce the permeability of the sediments in the area of recharge, and consequently the amount of water moving from the reservoir into the aquifer would be reduced.

A possible increase of the groundwater level in the floodplain alluvial deposits could result in groundwater problems for present and future sand and gravel operations.

In the area of Catfish Creek east of the Tennessee Colony reservoir, seepage and ponding due to a raised groundwater table is likely to present a problem. Its aspects were previously discussed in detail (Stephen F. Austin State University, 1972, p. B-46).

The possibility of waterlogging of the soil and the development of a swampy condition exists for the area of the town of Trinidad.

Excessive seepage of the lake water into the Mexia-Talco fault zones in the northern part of the Tennessee Colony reservoir is not anticipated. It has also, to our best knowledge, not been reported from Cedar Creek reservoir which is also intersected by these graben faults.

Region II

Lake Livingston is the only reservoir in Region II. In general, groundwater changes adjacent to the reservoir and along the canal will be similar in nature to those discussed for the Trinity Colony reservoir.

Region III

Creation of Lake Wallisville will probably not affect the groundwater conditions adjacent to the reservoir. It is likely that any possible recharge from the reservoir will be rejected because of the large amount of rainfall and the relatively "full" condition of the aquifer.

Pollution by Lignite Utilization - Region I

The strip-mining of lignite for fuel to generate electric power is a current trend in East Texas. This mode of power generation poses a possible pollution problem because many of the lignites contain sulfur and possibly mercury compounds. It presently appears that no economically feasible filter system is available to remove sulfur dioxide and possible mercury vapor from the stack emissions. This results in a considerable sulfur dioxide and mercury output by the emissions. Dispersal by winds has adverse effects in the downwind areas, and pollution of the local drainage system is also possible.

An increase in the acidity of surface waters is also possible in the neighborhood of the strip-mined areas because of the weathering of iron sulfide minerals which produce sulfuric acid.

The strip-mining and burning of lignite in the vicinity of Fairfield might create problems of this nature. Apparently, facilities to remove sulfur dioxide and possible mercury vapor from the stack emissions were not installed in the Big Brown Steam Electric Station. The gases are directly released into the atmosphere. Reaction of sulfur dioxide with atmospheric moisture results in the formation of sulfuric acid and acidic mist. Prevailing southwest to northeast winds widely disperse the gas, the acid, and the mercury vapor (?) in a downwind direction.

The acid and the mercury (?) have immediate harmful effects on the vegetation in the adjacent area. Concentration may occur in the drainage basin and in the reservoir water itself. Even traces of mercury in water are considered a health hazard since the mercury retention in the body is a cumulative process. Above a certain concentration it tends to destroy the nerve cells in the central nervous system (Kurland, Faro, and Siedler, 1960).

Slumping of the Clay Sequence in the Dallas-Fort Worth Area - Region I

Rocks of the Eagle Ford Group crop out along the Trinity River approximately 6 miles west of Dallas. The upper part of this unit consists mainly of dark shale with bentonitic beds. This unit tends to slump when wet or when overloaded. A low carbonate content contributes to this plastic behavior (Baldwin, 1972). The natural slope stability is less than 10 degrees.

The Trinity River cuts into strata of the Eagle Ford at two locations, in the vicinity of Grand Prairie and Greater Fort Worth International Airport. It is not anticipated that channel realignment in these areas will raise the groundwater level sufficiently to lubricate these clay beds. However, creation of a shipping canal with subsequent encroachment of industry toward the river might result in overloading and slumping toward the river. Undercutting of banks by highway construction or by strip-mining of gravel deposits should be avoided.

Acid Pollution by Quarry Operations on the Northern Flank of Butler Dome - Region II

Quarrying of sandstone on the northern flank of Butler Dome by the East Texas Stone Company poses a potential pollution problem. The weathering of large amounts of pyrite, FeS_2, in overlying material produces sulfuric acid causing an extensive acid surface water and pit water problem. The pit water which is pumped from the quarry into a nearby lake, and the surface drainage eventually enter into the future oxbow lake created by channelization affecting adversely the water quality.

Salt Pollution by the Texas Gulf Sulfur Company's Sulfur Plant - Region III

The discharge of highly saline water into the future Lake Wallisville creates a pollution problem. Possible contamination of the present river water, caused by groundwater movement and overflows during floods might already exist.

CONCLUSIONS

Channelization of the Trinity River and creation of reservoirs along this canal will have a number of immediate and long-term geological effects. The conclusions were drawn as follows:

Immediate Effects

Inundation or disturbance of portions of existing field production and disposal facilities of several oil and gas fields will result in loss of existing and potential income. If the affected fields are to continue to

operate, oil-pumping and storage stations, and oil and gas pipelines must be either elevated above the channel or lake level, relocated out of these areas, or abandoned. Elevation of well sites constitutes a sight pollution and a hazard to navigation. The danger of leakage and accidental brine and oil pollution remains high. Perhaps some of the undesirable channel excavation materials could be used for the elevation of the well sites if this technique is desirable. Relocation of the facilities appears to be a better solution.

Different disposal techniques of the oil-field brines must be practiced by the producing companies. The optimum alternative would be to pump the refuse into old, depleted disposal wells.

Future drilling in the reservoir areas and in portions of the floodplain affected by the channelization would be rendered more difficult.

Flooding of sand and gravel production areas will result in the loss of a valuable source of construction materials and income for the area as well. Sand and gravel should be effectively utilized for the many construction activities of the project, e.g., locks and dams, roads, parks, and recreational facilities.

Potential clay deposits in the area will probably not be adversely affected by the proposed canal and reservoirs. Rather, lower shipping costs resulting in lower overall production costs will possibly encourage greater development of these deposits.

Creation of the Wallisville reservoir will inundate the salt-polluted holding lake of the Texas Gulf Sulfur Company resulting in immediate entrance of this polluted water into the reservoir. Future discharge water will enter directly into the reservoir. The water pumping station that supplies water to the plant and rice farmers may suffer water losses due to alignment of the channel in that area cutting the pumping station off from the main river flow.

The type locality of the Eagle Ford Group west of Dallas should be investigated thoroughly prior to channel alignment activities to see what the effects on this section will be. It is not only a type locality but also a good fossil locality for Cretaceous swimming reptiles.

It is felt that flooding of the type locality of the Kerens member of the Wills Point Formation east of

Kerens, Navarro County, will not be an important loss. The locality has been adequately described, and a new satisfactory alternate could probably be located.

Several fossil localities along the cliffs of the Trinity River northeast of Kerens will be flooded. These localities are not considered to be significant because they are sparingly fossiliferous and contain mostly microfossils which may be located elsewhere. A possibly significant locality is the location which yields the foraminifera Cornuspira carinata.

Flooding of the type locality of the Onalaska member of the Catahoula Formation in Rocky Creek east of Onalaska, Polk County, is not considered important because it is generally no longer accepted as a type section.

The exact location of the fossil locality of the Fleming Formation known as Red Bluff, San Jacinto County, should be determined in order to determine the effect, if any, by the channelization.

Long-Range Effects

Several potential geologic problems are associated with channelization and creation of reservoirs but it is felt that these can be overcome if a sincere effort is made to do so under the strong guidance of the appropriate state and federal agencies. The channelization and inundation effects include the following aspects:

Potential pollution occurs which is caused by oil field brines and oil commonly retained by present practice in unlined pools or discharged onto the ground and into creeks. The contamination of the river and lake water by brines results in a considerable increase in water salinity. Potential oil and oil-field brine pollution can be avoided through careful production, storage, transportation, and disposal practices in compliance with state and federal regulations. The practice of pumping waste disposal into deep disposal wells must definitely be the rule adhered to. Provisions should be made for frequent monitoring of creeks draining the oil fields to insure that this practice is carried out.

Density stratification in the lake water of the Tennessee Colony, Livingston, and Wallisville reservoirs is possible, the denser saline water forming the lower water layer in the basins which causes anaerobic, toxic conditions.

Salinity also causes an increase in flocculation and sedimentation of clay minerals with an accelerated rate of silting-up.

The overall result is a decrease in water quality which makes water purification for drinking water production more costly. Flushing of the reservoir basins to remedy this situation would produce many adverse effects downstream including large fish kills.

The discharge of sediments by the tributaries into the shallow water sub-basins of these reservoirs will cause their progressive silting-up. This is also promoted by the possible increased salinity and clay flocculation of the water in the lakes.

Surface runoff from the Palestine and Butler salt domes during heavy rains may also contribute salt to the river water because salines exist on the surface of these domes, and the surface runoff from these domes eventually enters the river via local creeks.

The discharge of highly saline water from the Texas Gulf Sulfur Company's sulfur mining operations into a holding lake adjacent to the Trinity River indirectly poses a possible pollution problem for the Trinity River. The situation will become even more acute, however, when the waters of the Lake Wallisville reservoir cover the company's holding lake and future contaminated water is discharged directly into the lake.

Possible acid water pollution of the Trinity River is caused by the sandstone quarrying operations on the northern flank of the Butler Dome by the East Texas Stone Company. Creation of an oxbow lake with stagnant water adjacent to Butler Dome by channelization of the current river enhances further the acid water pollution problem. It can probably be overcome by proper treatment of acidic water and overburden dumps.

The strip mining of lignite for fuel to generate electric power by the new Big Brown Steam Electric Station northeast of Fairfield poses a possible pollution problem. These lignites contain sulfur and possibly mercury compounds. Apparently, sulfur dioxide gas will not be removed from the stack emissions which would also apply to possible mercury vapor. This results in a considerable sulfur dioxide and mercury emittance. Dispersal by winds has adverse effects in the downwind areas including pasture land, the reservoir, and its drainage area. An

increase in the acidity of surface waters in the neighborhood of the strip-mined area is also possible.

Frequent monitoring of the air and soil in a downwind direction should be conducted to insure that acid and mercury pollution are at a minimum. This also applies to surface water drainage from the area of the lignite mining to insure that acid pollution of local drainage networks is fully controlled.

The potential hazards involved in burning of lignite can be overcome by the installation of adequate removal equipment in the emission system of the plant. It may, however, require considerable research to come up with an effective and economical filtering system.

Much of the gas produced by gas wells is high in sulfur content, and the practice of burning undesirable amounts of gas increases the sulfur dioxide content of the atmosphere. This pollution can be avoided by elimination of such disposal techniques.

Disposal of large amounts of channel-cut material in excess of that required for construction fill may be accomplished by reclamation of excessively shallow lake water areas by building them up. The areas could be converted to park and recreational facilities. Other uses could include fill for roads and highways, rehabilitation of blighted areas caused by gravel and clay pits, and fill for possible elevation of oil field facilities in the project area.

Major and minor aquifers of the Trinity River Basin are the Trinity Group, Carrizo-Wilcox, Gulf Coast aquifers and the Woodbine, Queen City, and Sparta formations. Channelization will probably not significantly alter present groundwater conditions but the initial effect of the impoundment by reservoirs on the groundwater will be an increase in the water level in the wells and a more uniform level in stock ponds under water table conditions. Recharge to the aquifers from the reservoir may take place, except possibly in Region III where the "full" condition of the aquifers might preclude this. Recharge would increase the availability of groundwater for municipal and industrial use and will accelerate the artificial discharge by artesian wells in a downdip direction; however, the silting of the bottom of the reservoirs could reduce considerably the effectiveness of this artificial recharge.

Seepage and ponding in the area of Catfish Creek east of the Tennessee Colony reservoir may present a problem

Whether or not these conditions will occur depends upon the porosity and permeability of the Reklaw Formation. Its rock mechanical characteristics must be determined before definite conclusions can be drawn.

The possibility of the formation of swampy conditions exists in the Trinidad area and under the city itself, and must be considered.

Potential peat deposit areas in the flood plain of the Trinity River will be inundated by the reservoir. Peat could effectively be utilized as soil conditioner to help to build up the soil in parks and other recreational areas. However, it remains open as to whether a peat recovery would be feasible or not.

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CHAPTER III

EUTROPHICATION AND PESTICIDE ELEMENTS

by

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INTRODUCTION

The eutrophication and pesticide element of this report is part of a general environmental reconnaissance inventory of the Trinity River from Riverside Drive in Fort Worth, Texas to the proposed Wallisville Reservoir near Trinity Bay. Knowledge of the quality of water that will be available is essential in planning any water use project because the chemical character of the water determines its suitability for domestic, irrigation, recreational, or industrial purposes. The impact which a water resources project might have on the ecology of a river system can, to a certain extent, be predicted where present water quality conditions are known.

The primary objectives of this portion of the project will be to inventory the present eutrophic state of the Trinity River as well as other water quality parameters and to inventory the present application of insecticides and herbicides in the counties within the watershed of the study area as a possible index to the degree of pesticide pollution in various regions of the river. These data will then be used in the delineation of the areas having water quality problems and in the identification of probable sources of pollution, thus, indicating areas in which more detailed investigations are needed.

METHODS

Eutrophication Element

Stewart and Rohlick (1967) suggest several parameters which may be used as indices of eutrophication. The following parameters were used and will be discussed subsequent to the description of collecting stations:

A. Standing crop of phytoplankton
B. Chlorophyll concentrations in water samples
C. Oxygen concentrations
D. Phosphorus and nitrogen concentrations
E. Other

Twenty-seven collection stations were established on the Trinity River and its tributaries and were

assumed to be representative of water conditions in that portion of the river basin (Figure 13). The collection stations were located as follows:

Station 1: West Fork Trinity River three miles below Lake Worth Dam

Station 2: Clear Fork Trinity River one mile below Benbrook Dam.

Station 3. West Fork Trinity River, East 1st Street bridge below outfall from Riverside Drive Sewage Plant.

Station 4: West Fork Trinity River at Arlington Bedford Road below outfall from Village Creek Sewage Plant.

Station 5: West Fork Trinity River 100 yards below outfall from Trinity River Authority Sewage Plant.

Station 6: Trinity River in Dallas, Texas near bridge on Loop 12 below outfall of Dallas White Rock Sewage Plant.

Station 7: East Fork Trinity River near confluence of East Fork with the Trinity River.

Station 8: Trinity River at bridge on State Highway 34 near Rosser, Texas.

Station 9: Trinity River at bridge on State Highway 85 near Kemp, Texas.

Station 10: Trinity River at bridge on U.S. Highway 287 near Cayuga, Texas.

Station 11: Trinity River at bridge on U.S. Highway 79 near Elkhart, Texas.

Station 12: Trinity River at bridge on State Highway 7 near Crockett, Texas.

Station 13: Trinity River at bridge on State Highway 21 near Madisonville, Texas.

Station 14: Trinity River at bridge on U.S. Highway 59 near Livingston, Texas.

Station 15: Trinity River at bridge on State Highway 105 near Romayor, Texas.

Station 16: Trinity River at bridge on State Highway 162 near Moss Hill, Texas.

Station 17: Trinity River at bridge on U.S. Highway 90 near Liberty, Texas.

Station 18: Trinity River at Moss Bluff, Texas.

Station 19: Trinity River at bridge on Interstate 10 near Wallisville, Texas.

Station 20: Outfall Texas Gulf Sulfur south of Liberty, Texas.

Station 21: Long King Creek at bridge on FM 1988 near Livingston, Texas.

Station 22: Richland Creek at bridge on U.S. Highway 45 near Richland, Texas.

Station 23: Chambers Creek at bridge on FM 2859 near Kerens, Texas.

Station 24: Tehuacana Creek at bridge on FM 488.

Station 25: Blue Lake, near Longlake, Texas.

Station 26: Wolf Creek near Palestine, Texas.

Station 27: Saltwater Slough near Longlake, Texas.

A. Standing Crop of Phytoplankton

Standing crop of phytoplankton was based on collections of water samples at indicated collecting sites from January to June, 1972. Concentrations of samples for cell counts was accomplished by passing one liter of each water sample through a Foerst electrical plankton centrifuge three times (Hartmann, 1958). The volume of the concentrate was then determined and aliquots were taken for examination. Counts were determined using a phase contrast compound microscope and hemacytometer. Direct microscopic counts of phytoplankters were expanded to cells per liter by the equation given in Welch (1948). In general, organisms were identified to genus only.

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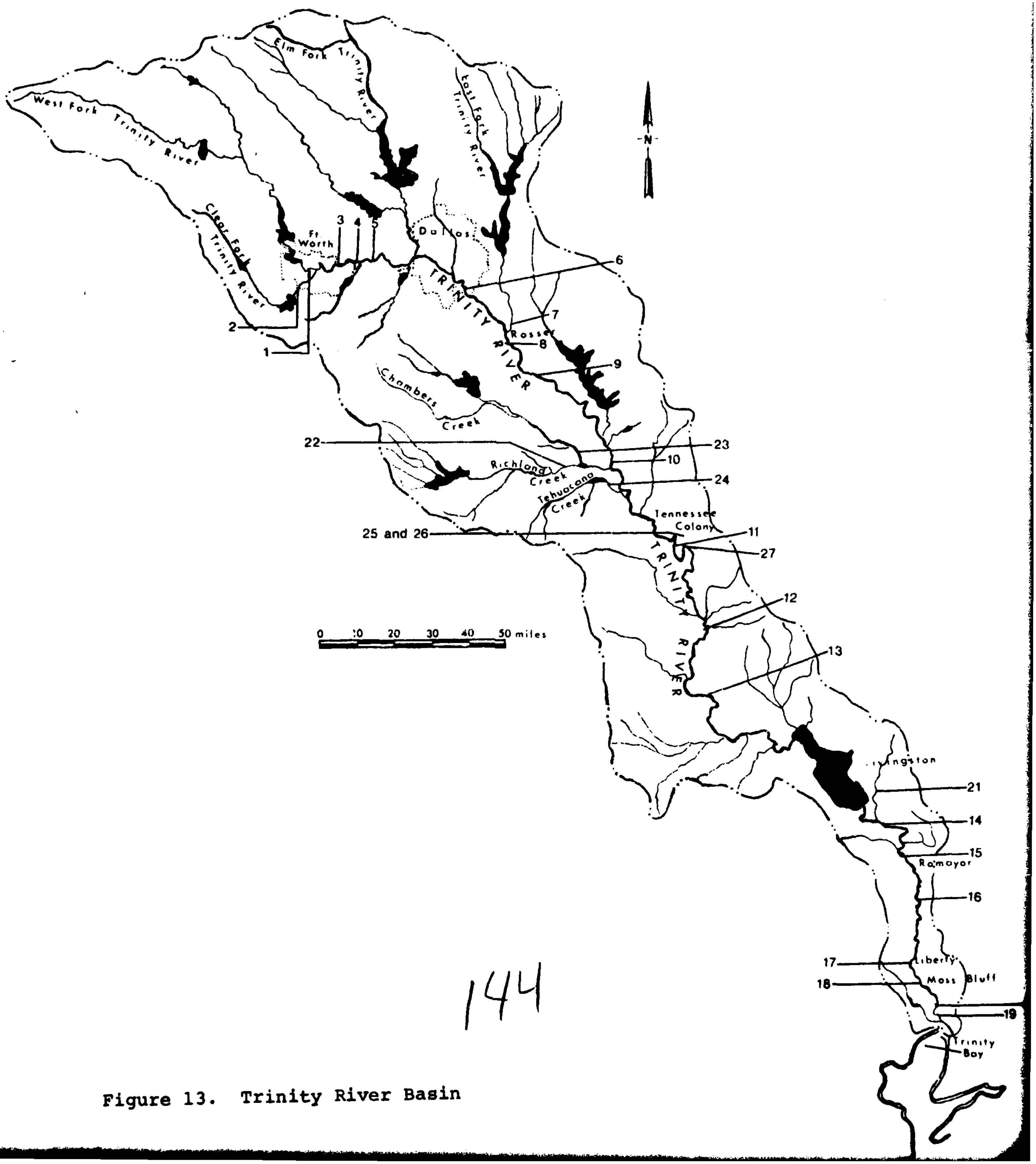

Figure 13. Trinity River Basin

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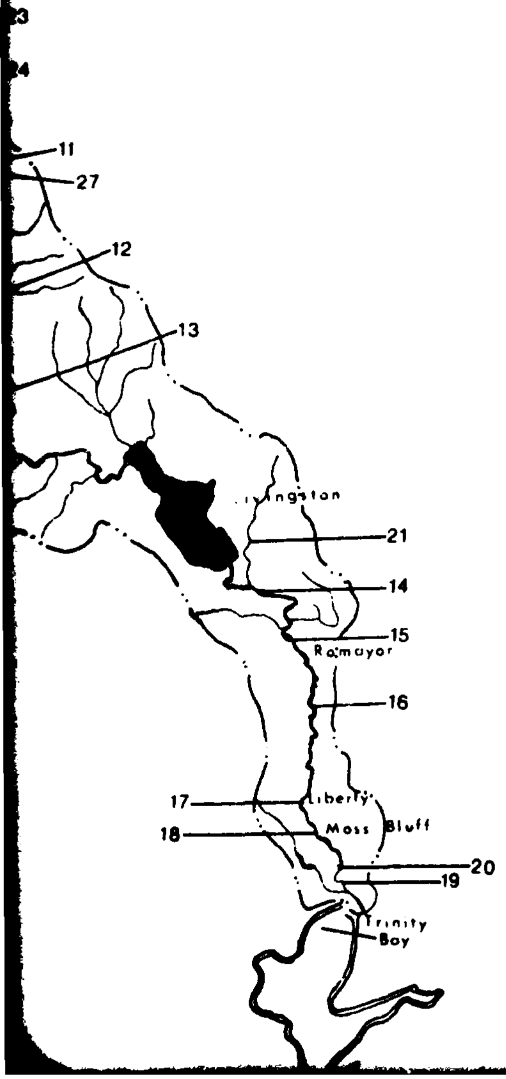
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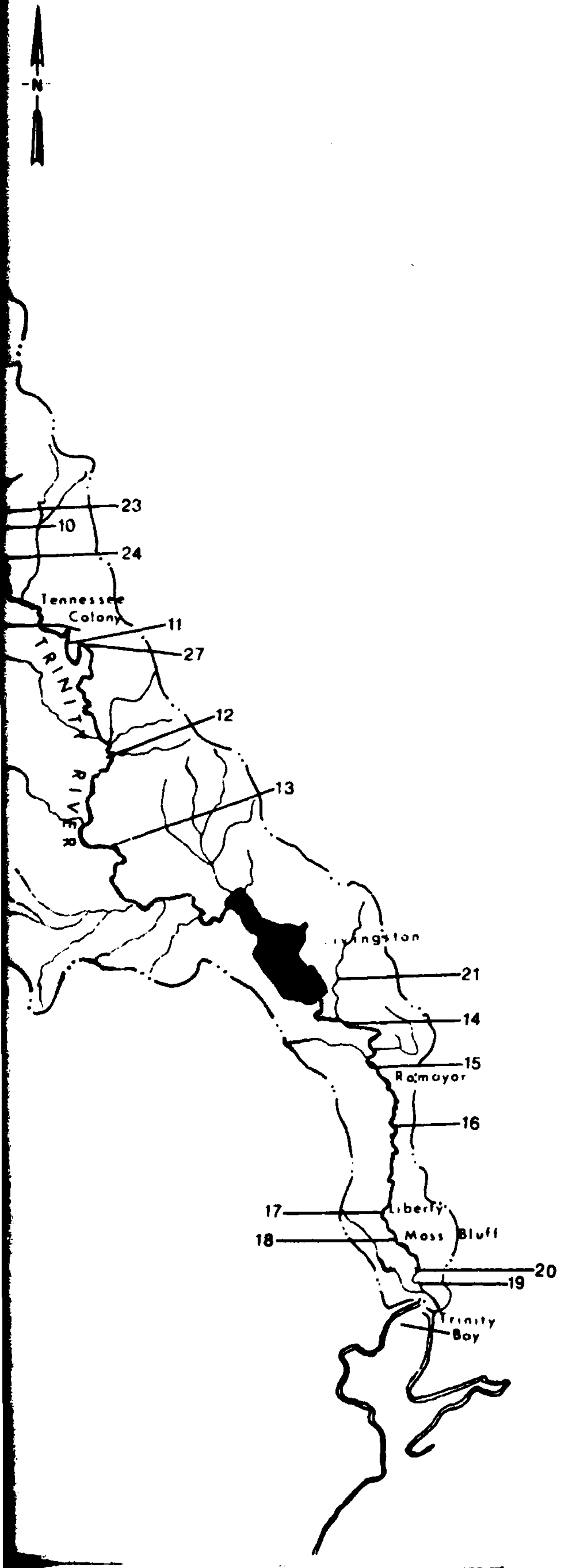
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B. Chlorophyll Determinations

Chlorophyll *a*, *b*, and *c* concentrations were determined from phytoplankton samples collected at each collection station. A 100 ml. aliquot of the phytoplankton sample was filtered through a millipore filter Type HA with 0.45 micron pores. The concentrations of chlorophyll *a*, *b*, and *c* were subsequently determined by the technique described by Richards and Thompson (1952) with revised equations by Parsons and Strickland (1964). Optical density values were determined using a Coleman Universal Model 14 Spectrophotometer. Values are reported as mg/m^3 chlorophyll *a* and mg/m^3 chlorophyll *a*, *b*, and *c*.

C. Oxygen Concentrations

Surface oxygen determinations were made at collection stations using a Yellow Springs Oxygen Analyzer Model 54.

D. Phosphorus and Nitrogen Determinations

Water samples for phosphate and nitrogen determinations were collected in polyethylene bottles at the water surface at collecting stations. Samples were kept at 4°C until analysis could be completed at the laboratory. Orthophosphates, nitrate nitrogen, nitrite nitrogen, and ammonium nitrogen were determined colormetrically. Orthophosphates were determined by the amino-napthol-sulfonic acid method, nitrate nitrogen was determined by the Cadmium reduction method, nitrite nitrogen was determined by the diazotization method and ammonia nitrogen by the Nessler method.

E. Other Chemical and Biological Parameters

a. Coliform bacteria - Estimates of the number of total coliform bacteria at selected collection stations were made using the multiple tube fermentation technique described by *Standard Methods* (1971).

b. Five day biochemical oxygen demand determinations were made monthly on water samples collected at collecting stations using the procedures outlined by *Standard Methods* (1971).

C. Chloride, as sodium chloride, was determined on water samples from collecting stations using the Mercuric

Nitrate Method as described in Standard Methods (1971). Water samples collected at station 17 near Liberty, Texas and station 19 near Wallisville, Texas were collected at the surface, at a midwater depth and near the bottom with a Kemmerer Water Sampler. All other water samples for chloride analysis were collected at a depth of one meter.

d. Sulfate was determined by the Barium Sulfate Turbidimetric Method. Water samples were collected at the surface.

e. Conductivity was determined by a Lab-line Lectro Mho-meter, and the pH of the water samples was determined in the lab with a Coleman Metrion IV pH meter.

f. Surface water temperature was determined in the field with a Yellow Springs Recorder Model 54 with a temperature probe.

g. Turbidity was determined for each water sample colorimetrically and is reported in Jackson Turbidity Units.

Population Survey of the Blue Crab, *Callinectes sapidus*

Survey of the populations of Blue Crab, *Callinectes sapidus* Rathbun was done using wire constructed crab traps, baited lines, and dip nets at three locations. One station was selected on the Trinity River near the bridge on U.S. Highway 59. Station two was located on the Trinity River near the bridge on State Highway 105. Station three was located on the Trinity River near the bridge on U.S. Highway 90. Specimens caught were measured, sexed, and weighed.

Pesticide Element

In order to assess the possible pollution of herbicides and insecticides in the study area, an inventory was made of pesticides used in agriculture enterprises in the Trinity River watershed. The inventory considered only that portion of the watershed from the Fort Worth-Dallas area to Trinity Bay. Records of phynoxy-herbicide usage in the study area were obtained from the Texas Department of Agriculture; however, there are no known sources of information on insecticide usage for the

counties in the study area which are obtained by an appropriate survey. In order to make estimates of insecticide usage in the specified areas, county extension agents have estimated the acreages treated by various crop categories. These estimates have involved only agricultural uses of insecticides and do not account for the industrial, municipal, or home owner use. Estimates of specific insecticide usage were then made by utilizing the application guidelines set forth by the Agricultural Extension Service of Texas A&M University for each crop category. It should be emphasized that these data are estimates and were not obtained through actual grower contacts.

RESULTS AND CONCLUSIONS

Eutrophication Element

Lee (1970) states that eutrophication is one of the most significant causes of water quality problems in North America. Ohle (1965) defines eutrophication as "enrichment in nutrients and increases of plant production," while Likens (1972) broadly defines eutrophication as enrichment with nutrients or organic matter that results in high biological productivity and a decrease in the volume within an ecosystem. In an undisturbed envorinment eutrophication can be a natural "aging" process in lakes, but the process can be accelerated by man's activities, which is called Cultural Eutrophidation.

The plant nutrients which are often considered to be the most significant for aquatic plant growth are orthophosphates, nitrates, nitrites, and ammonium. Currently a controversy exists among Limnologists as to which is more important in eutrophication, carbon or phosphorus. King (1972) and Fuhs, et al. (1972), respectively give evidence of carbon and phosphorus acting as "limiting" nutrients in the eutrophication of aquatic ecosystems. With reference to the critical levels of phosphorus and nitrogen in eutrophication, Sawyer (1945) and Vollenweider (1968) have reported that when inorganic nitrogen from ammonia and nitrates is equal or exceeds 0.3 ppm and the orthophosphate phosphorus content is equal or exceeds .01 ppm, one may expect nuisance plant "blooms" of algae and macrophytes. Mackenthun (1968) concluded that excessive growths of plants may be expected if total phosphorus exceeds

0.1 ppm in streams. Critical levels for nitrogen have been placed at 0.3 ppm of nitrate nitrogen or 0.6 ppm total nitrogen by Muller (1953) and 0.2 ppm nitrate nitrogen by Sylvester (1961). Lee (1970) reports that Sawyer's and Vollenweider's suggested critical levels for phosphorus and nitrogen are the best estimates available.

The nitrogen values (Table 9) exceeded these criteria at all collecting stations, with the highest values being recorded in the northern reaches of the river near Dallas, Texas where the river receives excessive quantities of domestic sewage. Leifeste and Hughes (1967) report that in the northern part of the basin where the river receives sewage, nitrate concentrations of 40 ppm are not uncommon. The range of concentrations of nitrates in their study was from 5.6 to 49 ppm near Rosser, Texas and 1.8 to 5.3 ppm near Romayor, Texas. Not all the nitrogen input is from domestic sewage. Forrest and Cotton (1970) report NIPAK Incorporated, a fertilizer plant, discharges 324 ppm nitrogen in their effluents. There is probably a significant input of nitrogen in run-off water from the cotton fields and other crops particularly in Ellis, Kaufman, and Navarro counties.

The ammonium values were highest in the study areas at Station 5 and 6 in Dallas, with values as high as 17.6 ppm of ammonium nitrogen (Figure 14). The average values steadily declined downstream reaching a mean value of 1.06 ppm ammonium nitrogen at Station 13 near Lake Livingston. Below Lake Livingston the ammonium was consistently below 1.0 ppm during the study period.

The high ammonium values, which are associated with domestic and industrial effluents, are of particular concern because of the toxic effects on aquatic biota. Doudoroff and Katz (1950) cite numerous studies reporting lethal concentrations of ammonium from 2 to 7 ppm with the highest at 25 ppm. Champ, Lock, McCullough, Bjork, and Klussman (1972) found shad, sunfish, and catfish to be the most susceptible in a pond treated with 37.7 ppm anhydrous ammonium. Belding (1927) reported that the toxic effect of ammonium is even more pronounced in water with low dissolved oxygen, as one of the symptoms of ammonium toxicity is reduced respiration. According to the toxicity values reported in the literature, the data in this study suggest that the region of the river between Stations 3, near Fort Worth, Texas, to Station 11, near Crockett, Texas, are problem areas with respect to ammonium toxicity.

Table 9. Water Quality Data from Trinity River and Selected Tributaries

Values in milligrams per liter except as indicated
* Jackson Turbidity Units
**Micromhos at 25°C

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO N^3	NO N^2	NH N^4	pH	BOD	Cl
Sta. 1	West Fork Trinity River - 3 miles below Lake Worth Dam											
7-7-72	6.6	27	10	441	42	0.1	t	t	0.15	6.4	6.0	35
Sta. 2	Clear Fork Trinity River - 1 mile below Benbrook Dam											
7-7-72	5.4	23	19	513	47	0.1	t	t	0.05	6.8	3.0	25
Sta. 3	West Fork Trinity River - East 1st Street Bridge below outfall from Riverside Drive Sewage Plant											
7-7-72	1.7	27	19	909	105	4.0	1.4	0.48	7.8	6.4	22.2	110
Sta. 4	West Fork Trinity River - Arlington Bedford Road below outfall from Village Creek Sewage Plant											
7-7-72	2.2	27	25	1020	125	4.4	1.5	0.43	12.8	6.6	9.6	110

continued

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO N^3	NO N^2	NH N^4	pH	BOD	Cl
Sta. 5	West Fork Trinity River - 100 yards below outfall from Trinity River Authority Sewage Plant											
7-7-72	-	-	39	1010	125	4.4	6.6	0.45	17.6	6.7	10.8	105
Sta. 6	Trinity River - in Dallas, Texas near bridge on Loop 12 below outfall of Dallas White Rock Sewage Plant											
7-7-72	0.3	29	53	991	130	7.3	7.0	0.005	17.6	6.3	26.4	105
Sta. 7	East Fork Trinity River - near confluence of East Fork with the Trinity River											
7-19-72	-	-	163	702	57	6.6	8.1	0.01	23.8	6.8	24.6	75
Sta. 8	Trinity River at Bridge on State Hwy 34 near Rosser, Texas											
6-28-72	2.5	32	67	779	165	5.6	0.5	.40	13.2	7.2	9.2	75
5-31-72	4.4	31	60	840	100	30.5	2.6	.28	16.5	6.9	14.7	-
4-5-72	3.4	19.7	8	928	95	12.0	1.79	.21	11.25	7.1	17.7	68.0

Table 9.continued

Date	O_2	°C	Turbi- bity*	Con- duct- ance**	SO_4	PO_4	NO N^3	NO N^2	NH N^4	pH	BOD	Cl
				Trinity River near Rosser, Texas, continued:								
3-8-72	2.0	18	12	735	105	11.5	1.4	.115	20.5	7.8	-	66.0
2-22-72	4.1	17	30	320	100	10.5	9.81	.19	15.04	7.8	10.3	42.3
2-8-72	6.3	9	28	730	82	12.0	9.85	.157	5.2	7.88	-	54.5
2-1-72	5.0	7	95	575	68	6.0	5.62	.28	4.72	7.6	25.2	63.5
Average	3.9	19.1	42.8	772	102	12.5	4.5	.23	12.3	7.4	15.4	61.6
Sta. 9	Trinity River at Bridge on State Hwy 85 near Kemp, Texas											
6-28-72	3.1	31	48	704	145	4.2	t	.27	10.6	7.1	6.8	70.0
5-31-72	5.7	29	60	900	125	27.5	9.8	.36	13.5	7.2	17.4	-
4-5-72	5.6	20	15	981	105	11.2	3.86	.14	12	7.1	15.6	87.5
3-8-72	4.0	18	20	810	130	11.5	1.3	.195	14.5	7.3	-	71.5
2-22-72	8.0	16	40	750	140	8.2	5.81	.39	12	7.95	15.3	48.5
2-8-72	7.2	10	20	720	70	8.4	7.77	.23	4.6	8.05	17.4	51.0

Table 9. continued

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO_3 N^3	NO_2 N^2	NH N^4	pH	BOD	Cl
	Trinity River near Kemp, Texas continued:											
2-1-72	5.0	7	70	619	70	6.25	5.704	.296	5.30	7.6	-	52.4
Average	5.5	18.7	39	783	112	11.0	5.7	.27	10.3	7.4	14.5	63.5
Sta. 10	Trinity River at Bridge on U.S. Hwy 287 near Cayuga, Texas											
6-28-72	4.0	31	46	489	76	1.9	1.4	.44	2.90	7.1	6.4	95.0
5-31-72	5.2	31	22	730	77	18.2	12.5	.45	.65	7.2	12.0	-
4-5-72	9.5	20	50	830	100	7.8	7.2	.80	6.0	7.29	15.6	73.5
3-8-72	6.1	18	30	849	100	12.0	10.0	.48	17.0	7.75	-	79.5
2-22-72	7.5	16	40	845	110	11	9.71	.29	14.8	8.0	11.2	20.5
2-8-72	7.9	9	48	700	71	7.2	7.85	.157	3.78	7.7	--	25.5
2-1-72	7.0	5	108	267	55	1.8	5.70	0.10	1.52	7.55	9.9	69.5
Average	6.74	18.6	49	673	84	8.6	7.8	.39	6.67	7.5	11.0	60.6

Table 9. continued

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO_3 N	NO_2 N	NH_4 N	pH	BOD	Cl
6-28-72	5.3	30	120	756	190	1.55	10.6	1.46	0.91	7.0	3.2	105
5-31-72	5.0	29	50	655	70	9.0	11.8	.059	.55	7.4	7.2	-
4-19-72	4.4	23	30	818	85	15.0	12.0	.45	3.6	7.4	6.6	70.0
3-8-72	5.2	17	15	849	105	6.8	10.28	.475	1.88	7.4	25.2	81.0
2-23-72	-	-	42	720	92	8.8	10.2	.60	4.4	7.95	5.7	26.0
2-22-72	6.0	11	70	675	100	7.5	11.78	.72	3.50	7.9	12.6	55.0
2-1-72	9.1	7	170	378	60	1.5	5.77	.03	.68	7.7	-	62.5
Average	5.8	19.5	71	693	100	7.2	10.35	.542	2.22	7.5	10.1	66.6
Sta. 12	Trinity River at Bridge on State Hwy 7 near Crockett, Texas											
6-28-72	4.6	30	204	518	110	2.05	2.0	.03	1.16	7.0	5.2	70.0
5-31-72	8.0	27	35	780	89	10.8	2.3	.141	.65	7.5	6.9	-
4-19-72	5.5	23	10	852	87	12.5	12.0	.375	.34	7.4	1.2	93.5
3-8-72	5.8	17	8	741	80	8.4	10.86	.24	.26	7.3	12.6	80.5

Table 9. continued

Date	O_2	°C	Turbi- dity	Con- duct- ance**	SO_4	PO_4	NO_2 N^2	NO_2 N^2	NH_4 N^4	pH	BOD	Cl
		Trinity River near Crockett, Texas continued:										
2-23-72	-	-	36	710	85	8.0	11.7	.495	1.6	7.7	2.7	25.5
2-22-72	6.0	12	55	640	89	7.0	12.2	.60	3.2	7.9	-	55.0
2-1-72	9.8	6	118	360	45	1.6	3.78	.02	.64	7.6	10.8	64.0
Average	6.6	19	66	657	83	7.2	7.83	.272	1.12	7.4	6.6	64.8
Sta. 13	Trinity River at Bridge on State Hwy 21 near Madisonville, Texas											
6-28-72	6.2	32	62	562	210	9.7	2.5	0.07	0.60	7.1	4.4	63.5
5-31-72	7.4	30	12	732	80	6.75	8.2	.069	.6	7.7	5.4	-
4-19-72	5.2	23	23	761	82	6.9	10.5	1.83	1.2	7.3	9.6	83.5
3-8-72	5.8	17	10	750	80	7.0	9.85	.40	.38	7.3	11.4	77.5
2-23-72	-	-	32	712	92	5.3	11.4	.49	0.86	7.15	-	24.5
2-22-72	6.2	12	40	620	63	4.65	10.94	.56	3.1	7.8	7.2	65.0
2-1-72	9.8	6	120	340	45	1.6	2.984	.017	.70	7.6	-	68.0
Average	6.8	20	43	640	93	5.99	8.05	.491	1.06	7.4	7.6	63.7

Table 9. continued

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO_3 N	NO_2 N	NH_4 N	pH	BOD	Cl
Sta. 14	Trinity River at Bridge on U.S. Hwy 59 near Livingston, Texas											
6-19-72	8.8	25	0	312	30	.21	5.9	0	0.43	7.1	5.4	25
6-7-72	7.8	27	-	279	17	.21	-	.003	.3	7.3	7.2	25
6-1-72	8.8	25	5	322	20	.36	5.8	.005	.48	7.3	5.4	40
Average	8.5	25.7	1.7	304	22	.26	5.85	.003	.40	7.2	6.0	30
Sta. 15	Trinity River at Bridge on State Hwy 105 near Romayor, Texas											
6-19-72	8.5	27	31	289	30	.19	7.1	0.013	0.31	7.2	10.8	25
6-7-72	7.5	28	29	278	25	0.13	2.5	0	.12	7.6	4.2	30
Average	8.0	27.5	30	284	27.5	.16	4.8	.007	.22	7.4	7.5	27.5
Sta. 16	Trinity River at Bridge on State Hwy 162 near Moss Hill, Texas											
6-1-72	8.5	27	5	331	16	.275	5	0	.52	7.15	6.6	52.5

Table 9. continued

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO_3 N	NO_2 N	NH_4 N	pH	BOD	Cl
Sta. 17	Trinity River at Bridge on U.S. Hwy 90 near Liberty, Texas											
6-21-72	5.0	32	21	-	28	.15	4.7	t	0.37	7.0	7.8	30
6-19-72	7.5	28	29	286	28	.15	0.5	0	0.41	7.2	6.0	30
6-1-72	7.5	28	12	350	19	.30	6	.003	.50	7.2	2.4	55
Average	6.7	29	20.7	318	25	.20	3.7	.0015	.43	7.1	5.4	38
Sta. 18	Trinity River at Moss Bluff, Texas											
6-21-72	5.5	32	33	-	31	.23	6.9	.01	0.40	6.9	6.6	40
Sta. 19	Trinity River at Bridge on Interstate 10 near Wallisville, Texas											
6-21-72	5.0	32	44	470	49	.69	3.9	.015	0.40	7.2	6.6	115
Sta. 20	Outfall Texas Gulf Sulfur south of Liberty, Texas											
7-26-72	-	-	40	-	310	-	-	-	-	-		-14,750

Table 9. continued

Date	O$_2$	°C	Turbidity*	Conductance**	SO$_4$	PO$_4$	NO$_3$ N	NO$_2$ N	NH$_4$ N	pH	BOD	Cl
Sta. 21	Long King Creek at Bridge on FM 1988 near Livingston, Texas											
6-19-72	-	-	23	253	15	.37	4.5	0.032	0.77	6.9	4.8	45
6-7-72	9.1	28	20	320	15	0.2	-	0	.3	6.7	6.0	35
Average	-	-	21.5	286.5	15	.285	4.5	.016	.535	6.8	5.4	40
Sta. 22	Richland Creek at Bridge U.S. Hwy 45 near Richland, Texas											
7-19-72	-	-	63	384	65	.15	10	t	.65	6.75	18.0	334
Sta. 23	Chambers Creek at Bridge on FM 2859 near Kerens, Texas											
7-19-72	-	-	90	896	170	4.2	7.5	0.33	.96	6.45	9.6	140
Sta. 24	Tehuacana Creek at Bridge on FM 488											
7-19-72	-	-	66	664	97	0.1	5	.005	.59	6.77	6.9	830

Table 9. continued

Date	O_2	°C	Turbidity*	Conductance**	SO_4	PO_4	NO_3 N	NO_3 N	NH_4 N	pH	BOD	Cl
				I-10 Vertical Profile Data								
7-26-72	-	-		-		-	-	-	-	-	-	
Surface			13		36							105
Mid-water			16		38							125
Bottom			25		37							135
				Liberty Vertical Profile Data								
7-26-72	-	-		-		-	-	-	-	-	-	
Surface			38		42							30
Mid-water			10		37							30
Bottom			27		42							35
Sta. 25				Blue Lake near Long Lake, Texas								
7-31-72	-	-	-	-	250	-	-	-	-	8.35	-	540
Sta. 26				Wolf Creek near Palestine, Texas								
7-31-72	-	-	-	-	71	-	-	-	-	7.1	-	55

Table 9. continued

Date	O_2	°C	Turbidity*	Conductanct**	SO_4	PO_4	NO_3 N	NO_2 N	NH_4 N	pH	BOD	Cl
Sta. 27		Saltwater Slough near Long Lake, Texas										
7-31-72	-	-	-	-	180	-	-	-	-	8.3	-	8250

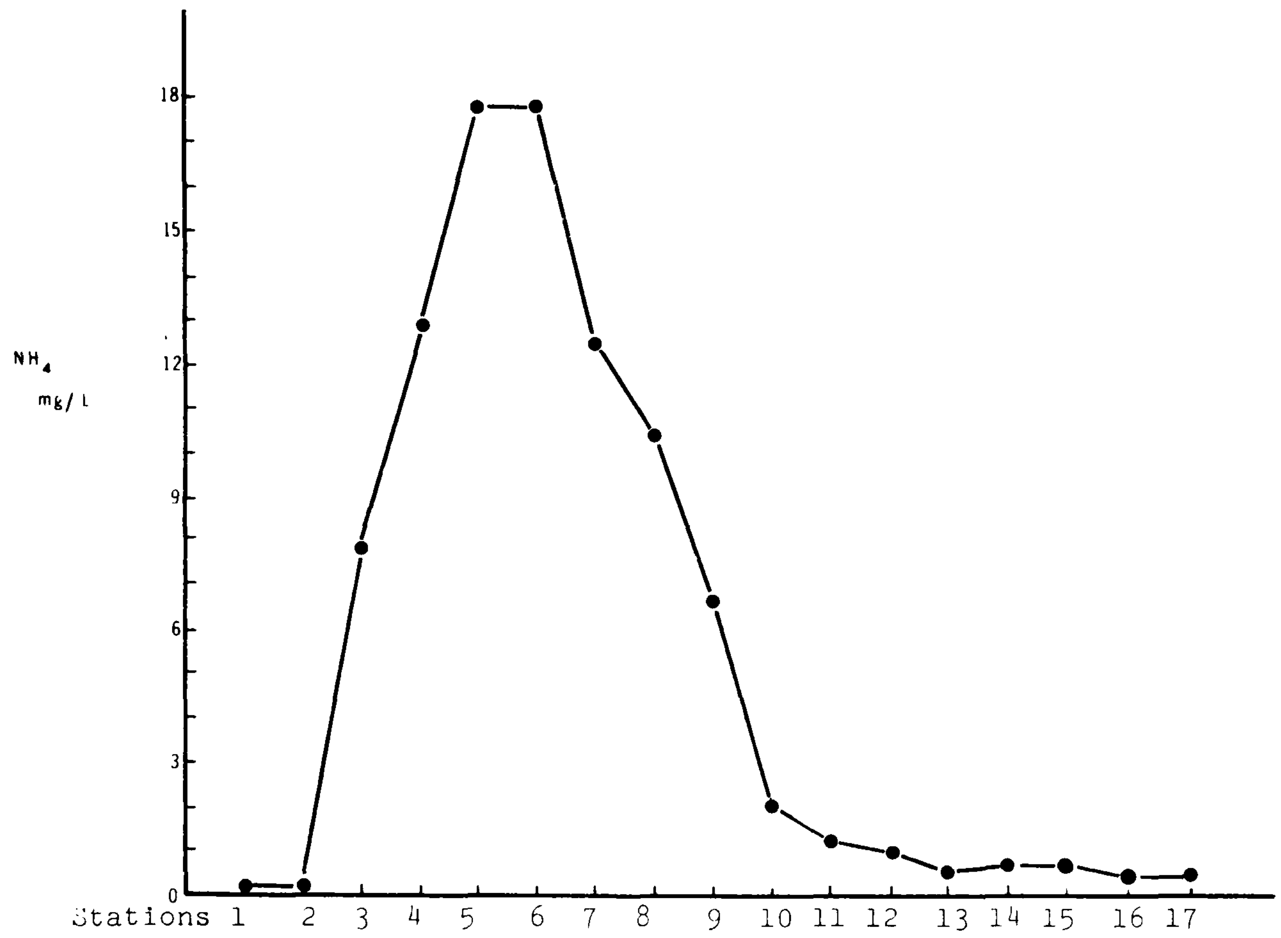

Figure 14. Average Ammonium Nitrogen at Indicated Collection Stations in the Trinity River

The average nitrate and nitrite values recorded during this study generally increased downstream from the Dallas area, Station 11, probably due to the oxidation of ammonium to nitrites and nitrates (Figures 15 and 16). The average nitrate values increased in concentrations downstream from Dallas reaching the highest average at Station 11 at Highway 59 near Elkhart, Texas at 10.35 ppm nitrate nitrogen. The enriching influence of the nitrate peak on phytoplankton is probably reflected in the highest average concentrations of both Chlorophyll a and the total of Chlorophyll a, b, and c also at Station 11 (Figures 17 and 18). The average phytoplankton chlorophyll concentrations generally increase downstream from Station 8 near Rosser, just as do the average nitrate values, with a peak at Station 11. The phytoplankton community reached the highest average populations at Station 12 near Crockett, Texas; however, the value was only slightly higher than at Station 11, where the nitrate peak was found. The average nitrite values were highest in the northern part of the study area with an average value of .54 ppm nitrite nitrogen at Station 11, but appeared to be drastically reduced by Lake Livingston, with values never exceeding 0.01 ppm below the lake.

Although the ammonia and nitrite averages decline abruptly below Lake Livingston, the nitrate values remain at a highly eutrophic level, with the lowest average value 3.7 ppm nitrate nitrogen at Station 17 near Liberty, Texas.

The absence of a decline in nitrate nitrogen below Lake Livingston suggests that the lake contains high nitrate concentrations and that the water never fully recovers from the high nitrogen input from the northern part of the basin. Although the water quality of Lake Livingston was not a part of this study, a very heavy phytoplankton bloom was observed in the lake near the dam site on June 7, 1972. The portion of the lake is extremely eutrophic where the Trinity River flows into Lake Livingston with excessive growth of phytoplankton and vascular plants very evident.

Orthophosphate

The orthophosphate concentrations on the northern reaches of the Trinity River were very high during this study. The average concentration at Station 8 at Rosser, near Dallas, Texas, was 12.5 ppm, with average

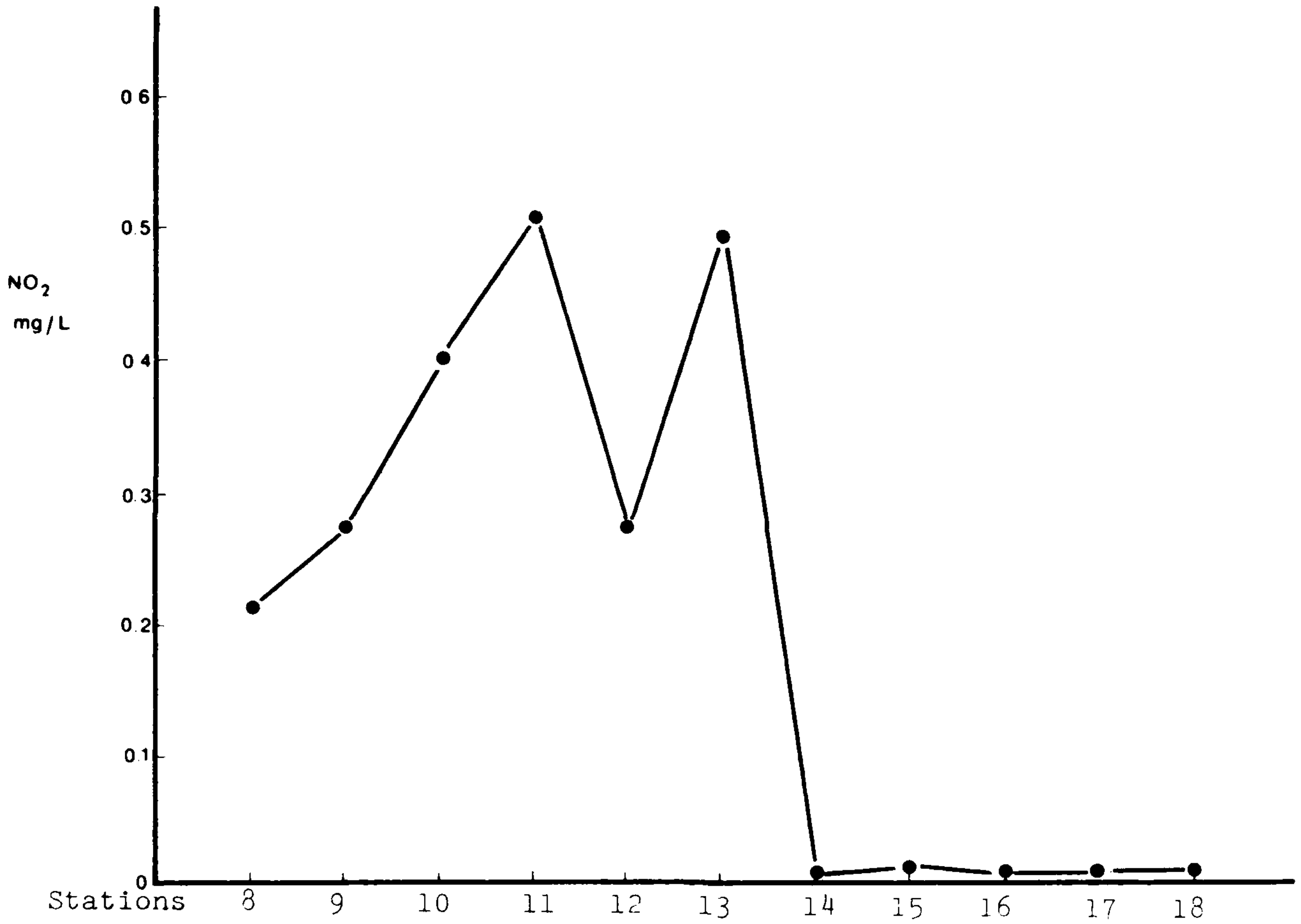

Figure 15. Average Nitrite Nitrogen Concentrations at Indicated Collection Stations in the Trinity River.

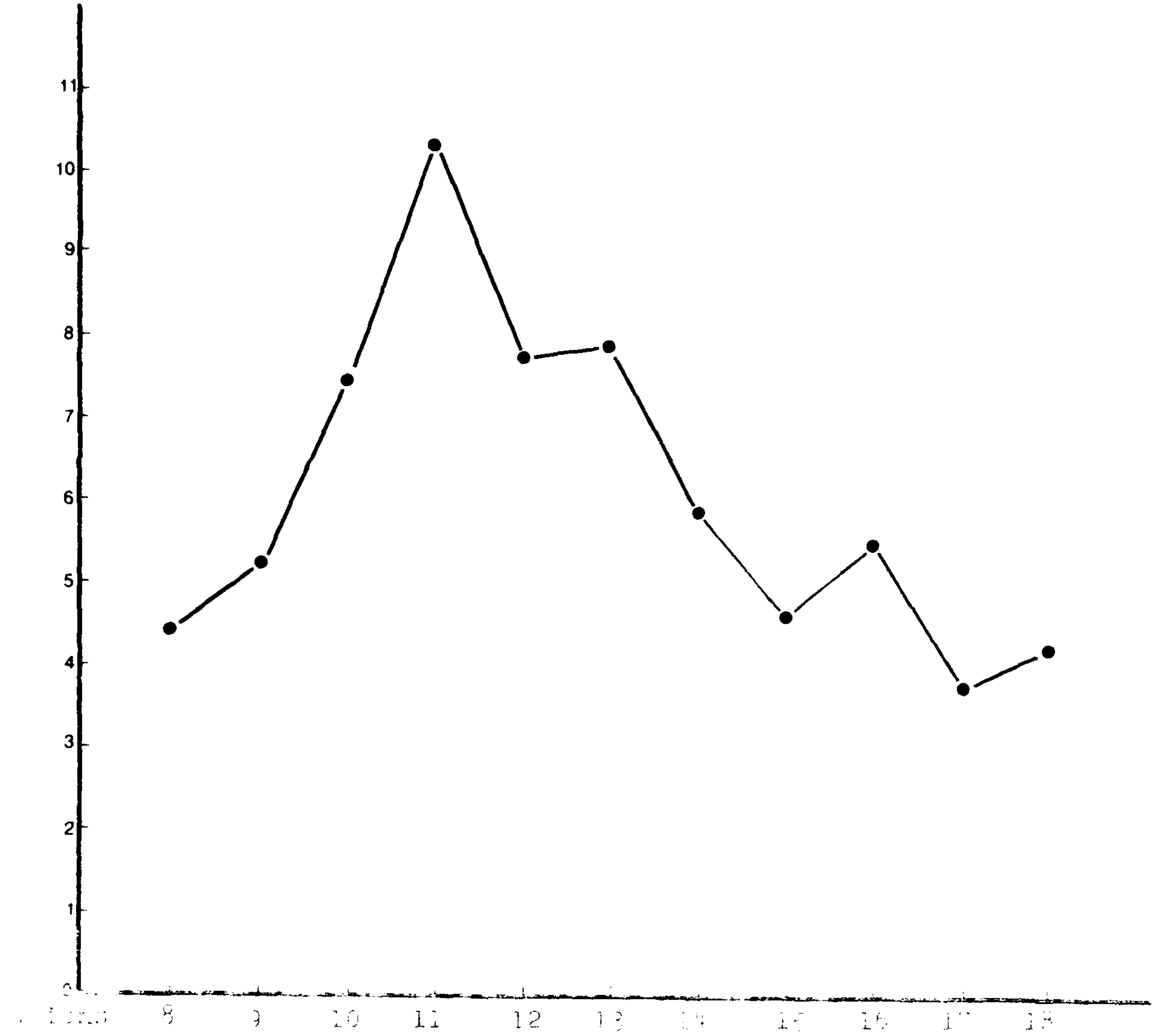

Figure 16. Nitrate Nitrogen Concentrations at Indicated Collection Stations in the Trinity River

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A SURVEY OF THE ENVIRONMENTAL AND CULTURAL RESOURCES OF THE TRI--ETC(U)
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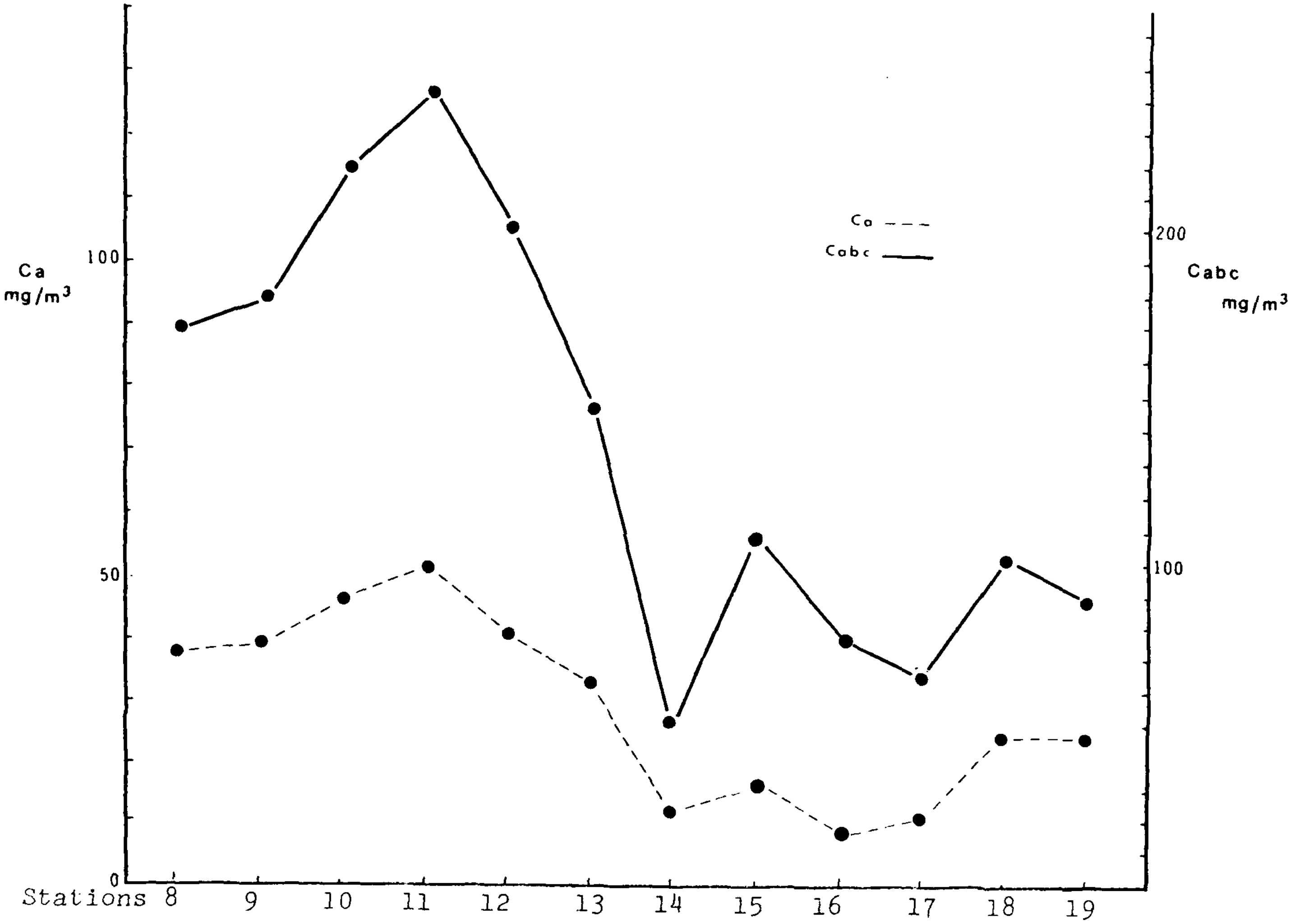

Figure 17. Average Chlorophyll Concentrations at Indicated Collection Stations in the Trinity River

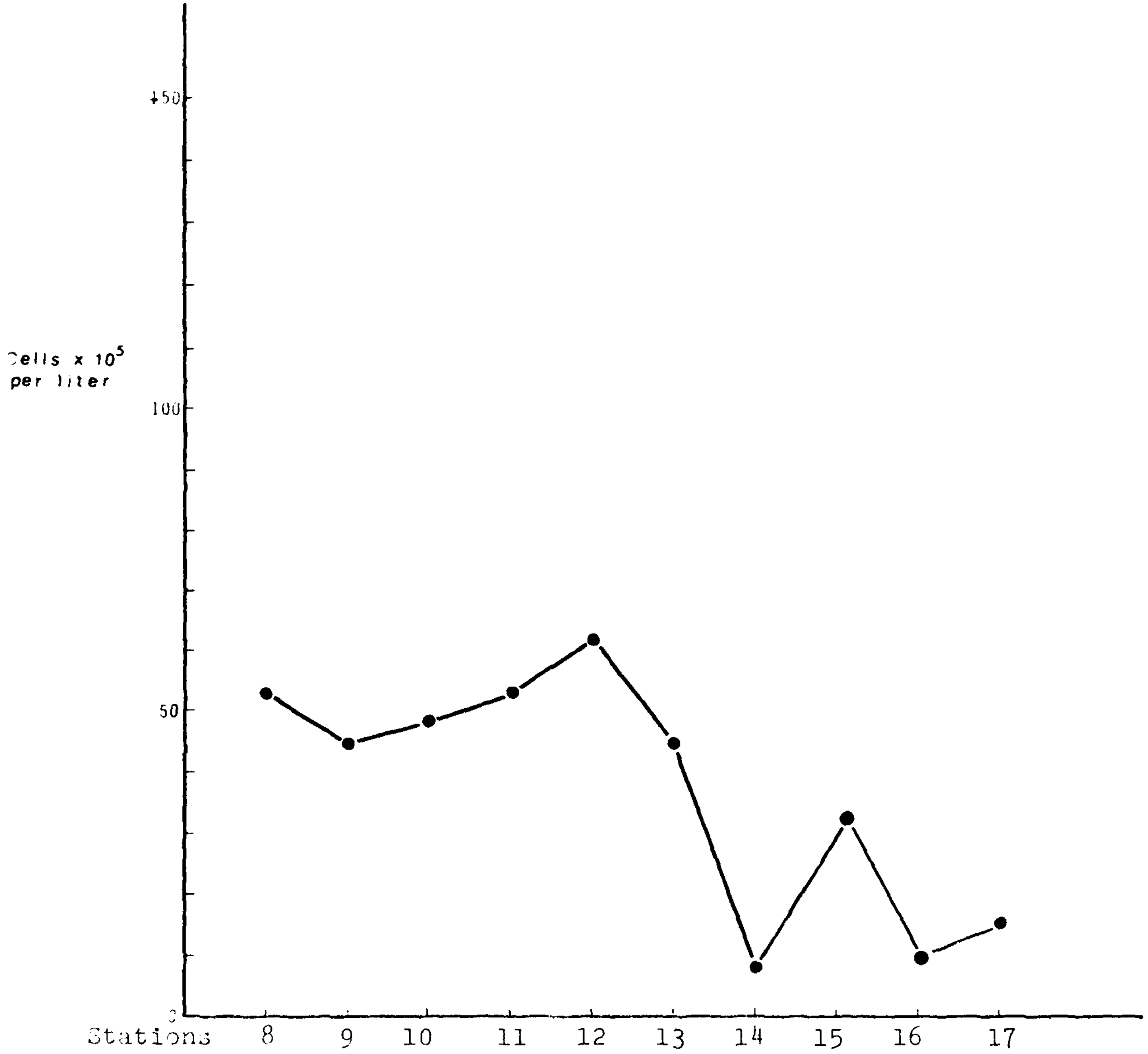

Figure 18. Average Cell Counts for Phytoplankton at Indicated Collection Stations in the Trinity River

concentration decreasing downstream to 5.99 ppm at Station 13 near Madisonville, Texas, just above Lake Livingston (Figure 19). Lake Livingston appears to remove a great quantity of orthophosphate from the water with an average concentration of 0.26 ppm orthophosphate at Station 14, ten miles downstream from the Lake Livingston dam site. At Station 15, near Romayor, Texas, a value of 0.16 ppm orthophosphate was recorded, one of the lowest for the river during this study.

The high phosphate content above Lake Livingston is probably due to high quantities of phosphate-containing detergents in domestic sewage from the Dallas-Fort Worth area. Domestic sewage is not the only source of phosphate contamination in the river. Forrest and Cotton (1970) report that NIPAK, Incorporated, a fertilizer plant near the Trinity River at Trinidad, Texas, discharges 176 ppm P_2O_5 in their effluents. Run-off water from the extensive agricultural enterprise in the river basin near Dallas is probably a significant source of phosphorus. Sawyer (1947), reports that agricultural land in Wisconsin contributes up to 0.6 lb. of phosphate phosphorus per square mile per day. Weibel (1964) reports that urban run-off may also contribute high amounts of phosphates.

The decrease in phosphates downstream is due to uptake and deposition by aquatic organisms. Hays, et al. (1958), have reported that phytoplankton, benthic algae, vascular plants, bacteria, and other organisms contribute to the uptake of this nutrient from fresh water. Reid (1961) reports that about four percent of the phytoplankton cells that take up inorganic phosphate are sedimented to the bottom each day.

The phytoplankton counts, in the Trinity River downstream from Lake Livingston are relatively low and orthophosphate concentrations suggest that phosphorus is probably "limiting" the development of this community since the nitrate concentrations in this region are relatively high.

BOD and Coliform Bacteria

Biochemical oxygen demand and total coliform bacteria determinations reflect the high quantity of domestic sewage polluting the Trinity River. BOD values were highest near Dallas, Texas with one value reaching greater than 26 ppm, but the values declined progressively

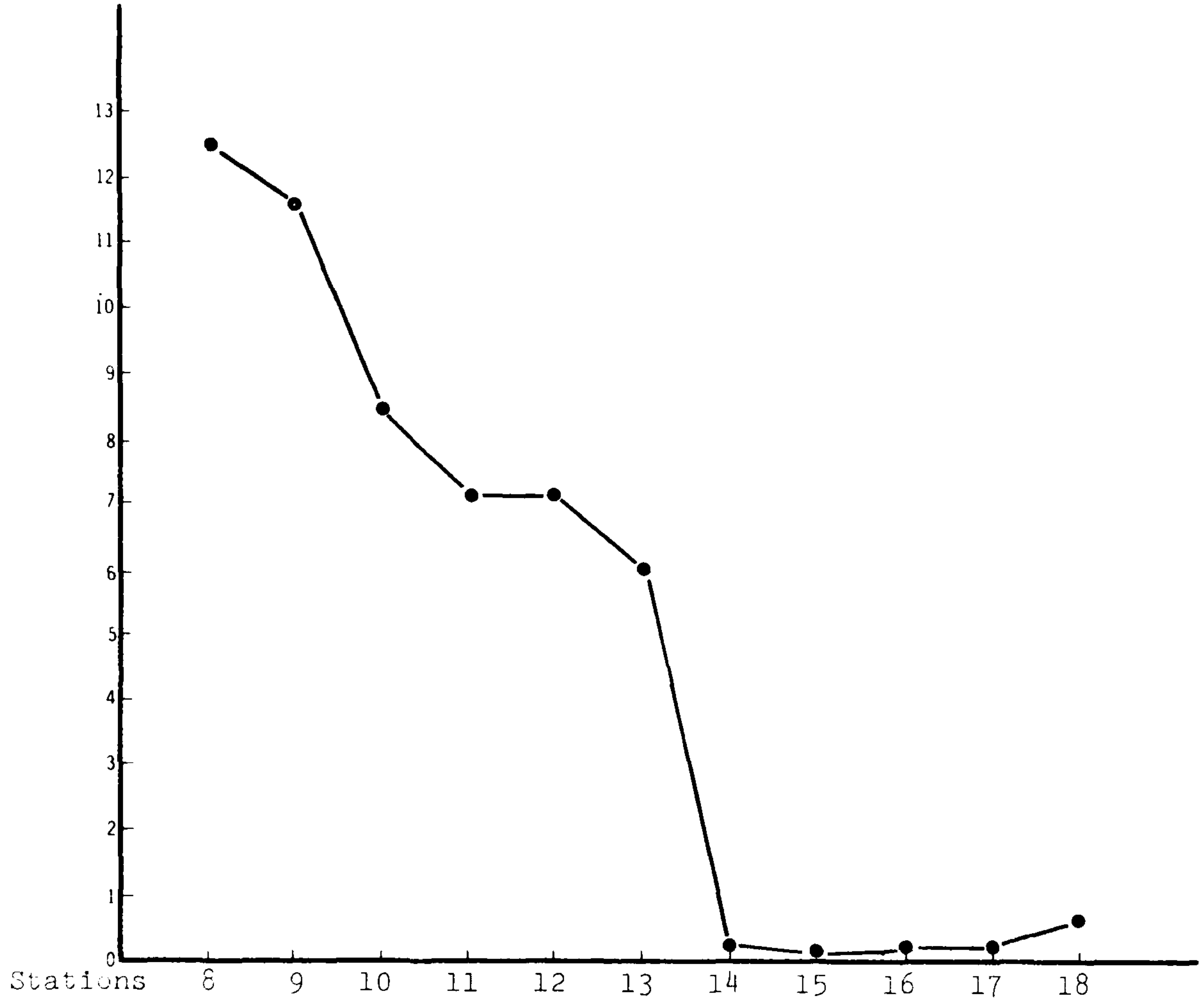

Figure 19. Average Orthophosphate Concentrations at Indicated Collection Stations in the Trinity River

downstream and never exceeded 6.6 ppm at any station below Lake Livingston (Table 10). Texas Water Quality Standards, FWPCA (1969) limit the BOD from tidal waters to Rosser, Texas to 10.0 ppm, from Rosser to West Fork headwaters to 15.0 ppm, East Fork to 10.0 ppm, and Elm Fork to 4.0 ppm. From Station 3 near the Riverside Drive Sewage Treatment Plant downstream to Station 11 on Highway 79 near Elkhart, the average BOD values usually exceed these criteria. The high BOD values in this region of the river basin are not due to sewage plant effluents alone. Forrest and Cotton (1970) report that Texas & Pacific/Missouri Pacific R.R. Company in the Dallas-Fort Worth area discharge effluents with a BOD of 173 ppm. American Manufacturing Company in the Dallas-Fort Worth area discharges effluents with 144 ppm BOD, and Proctor and Gamble, Incorporated, in the same area, have a permit to discharge 1,888 ppm BOD. The East Fork Trinity appears to contribute a significant BOD load to the Trinity River with one recorded BOD of greater than 26.4 ppm. The source of the high BOD in the East Fork is probably domestic sewage, strongly suggested by an MPN total coliform count of 2.4 million organisms per 100 ml. of water.

Total coliform bacteria populations were also highest near the Dallas-Fort Worth area, reflecting the quantity of sewage polluting the river in that region (Table 10). MPN values, frequently exceeding one million coliform bacteria per 100 ml. of water in the Dallas area, generally decreased downstream with MPN values as low as 400 recorded at Station 17 near Liberty, Texas. Texas Water Quality Standards FWPCA (1969) suggests an MPN limit of 20,000 organisms per 100 ml. The high MPN values observed above Station 12 suggest that from an epidemiological standpoint, the use of the water for recreation would be limited.

Oxygen

High biochemical oxygen demand and high turbidity create low dissolved oxygen conditions in the upper regions of the study area, particularly near Station 6 at Dallas, Texas where a dissolved oxygen value of 0.3 ppm was recorded (Table 9). The Texas Water Quality Standards (FWPCA, 1969) limit the dissolved oxygen to not less than 4.0 ppm in the Trinity River downstream to the tidal waters at Trinity Bay. The Federal Water Pollution Control Administration (1968) points out that for a diversified warm water biota, including game fish, the dissolved oxygen concentration should be above 5 ppm

Table 10. Total Coliform.
MPN X 10^5 / 100 ml.

Date	Station 3	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13
9-18-71	-	-	23	-	1.1	.021	.028	.43	.24	.043
10-2-71	-	-	1.1	-	.46	.023	.093	.023	.023	.043
11-4-72	-	-	1.1	-	1.1	1.1	.75	.24	.24	.093
11-27-71	-	-	110	-	0.4	.024	.024	.093	.093	.093
6-21-72	-	-	-	-	1.1	1.1	.041	.043	.075	.007
7-8-72	1.5	4.6	460	-	-	-	-	-	-	-
7-18-72	-	-	-	2.4	-	-	-	-	-	-

Table 10. continued

Date	Station 14	Station 15	Station 16	Station 17	Station 18	Station 19	Station 21
6-2-72	.007	-	.007	.004	-	-	-
6-7-72	.24	.043	-	-	-	-	.011
6-19-72	.015	.007	-	.07	-	-	-
6-21-72	-	-	-	.043	.24	.043	-

and that normal seasonal and daily variations be above this concentration. Under extreme conditions, the concentrations may range between 4 and 5 ppm for short periods if the quality of the water is favorable in all other respects. The region of the Trinity River from Station 3 at the Riverside Drive Sewage Treatment Plant downstream to Station 9 on Highway 85 near Kemp, Texas, appears to be a problem area with respect to the oxygen criteria set forth in the above publication. Other stations below these areas on the river may not conform to these criteria, however, seasonal and diurnal sampling was limited in the reconnaissance inventory study. Dissolved oxygen values below Lake Livingston were always above 5 ppm and appear in fact to support a diverse aquatic community.

"Black water rises" frequently occur during floods resulting in low or zero dissolved oxygen concentrations. This phenomenon is thought to be caused by extensive deposits of organic matter with a high oxygen demand, deposited on the bottom during low flow, being swept downstream by high water conditions. This problem is most acute on the river above Lake Livingston to the Dallas-Fort Worth area and is frequently reported to be the cause of large fish kills in this region of the basin.

The extreme conditions of eutrophication in the upper regions of the river also account for depressed oxygen values. Eutrophication generally manifests itself in the production of excessive plant growth, in this case phytoplankton. While the algae produce oxygen during the day by photosynthesis, oxygen consumed in respiration is so extensive by the dense populations of algae, bacteria and other organisms, that very low dissolved oxygen values are common at night, which creates a stress condition for a diverse aquatic community. In addition, excessive plant production in eutrophic conditions is frequently accompanied by a "die-off" of a large part of the population followed by decay, which also contributes to depressed dissolved oxygen values.

Chlorides

Texas Water Quality Standards (FWPCA, 1969) limit the chloride concentration in the Trinity River to 125 ppm from Rosser to tidal waters near Trinity Bay and to 100 ppm from Rosser upstream to the West Fork headwaters. The East Fork is limited to 40 ppm and the Elm Fork to 80 ppm. In samples taken at Station 3 at the

Riverside Drive Sewage Treatment Plant, downstream to Station 6 at Loop 12 in East Dallas, the chlorides exceed 100 ppm (Table 9). The excessive chloride concentrations in this region of the river are probably due to municipal and industrial waste discharges. The stations below Dallas to Lake Livingston never had chloride concentrations over 100 ppm and averages were usually in the range of 60 ppm. Below Lake Livingston, the values were usually in the range of 25 to 40 ppm with the exception of Station 19 at the bridge on Interstate 10 near Wallisville, Texas, where a surface value of 115 ppm chlorides was recorded. On July 26, 1972 a vertical profile of chloride values was analyzed at Station 19 and a surface value of 105 ppm, midwater depth value of 125 ppm, and a bottom water value of 135 ppm was recorded. The increase of chlorides near the bottom was probably due to intrusion of salt water upstream from Trinity Bay, with the heavier salt water concentrating on the bottom. A vertical profile at Station 17 near Liberty, did not produce values significantly different from upstream stations.

The use of water from the Trinity River for irrigation of rice crops makes the chloride concentration rather critical. Ireland (1956) reports that rice can tolerate water containing chloride concentrations up to 350 ppm; however, Leifeste and Hughes (1967) report that rice farmers are sometimes unable to use water from the Trinity River for irrigation because of salt water intrusion upstream from Trinity Bay. The Devers Pumping Station at Moss Bluff, Texas reports that during low flow the volume of freshwater is not sufficient to prevent salt water from being pushed upstream. Leifeste and Hughes (1967) found that chlorides in much of the Trinity River Basin is usually less than 50 ppm; however, the Elm Fork Trinity River contained concentrations over 300 ppm due to oil-field brine. Oil-field brines also appear to be reaching the waters of Richland, Chambers, and Tehuacana creeks. Osborne and Shamberger (1960) report that 83,000 barrels of brine per day were being discharged on the surface and approximately 61,500 barrels per day drained directly into Chambers and Richland creeks. Leifeste and Hughes (1967) report that chloride concentrations in these creeks are often greater than 1000 ppm and sometimes as high as 7000 ppm. Chloride concentrations determined in this study, while high (Tehuacana Creek had concentrations of 830 ppm chlorides), they were less than the previous values. The effects of the waters from these streams might be seen in the average chloride values at Stations 10 and 11. Station 10 at

Cayuga is upstream from these creeks and had an average chloride concentration in water samples of 60.6 ppm. The next downstream station, Station 11 at Highway 79 near Elkhart and below the three creeks, had an average chloride concentration of 66.6 ppm chlorides.

Some local sources near Station 11 may contribute to the higher chloride levels at that station. Saltwater Slough, a tributary near Station 11, contained 8,250 ppm chlorides, probably from oil-field brine. A salt dome near Palestine, Texas may contribute chlorides to tributaries near Station 11, but one such tributary, Wolf Creek near Palestine, contained only 55 ppm chlorides. However, the water samples from Wolf Creek were taken during dry weather and may contain much higher chloride concentrations during or following a heavy rain, with the run-off water introducing the additional salt. Chloride pollution of the Trinity may occur at Blue Lake, located upstream from Station 11 and near a mining operation. Water samples from this body of water contained 540 ppm chlorides and may contribute salt to the river by seepage or overflow.

Forrest and Cotton (1970) report that NIPAK, Incorporated, a fertilizer plant on the Trinity River near Trinidad, Texas have reported a chloride discharge of 325 ppm. The highest source of brine pollution was found in the effluent from Texas Gulf Sulfur south of Liberty, Texas with one value of 14,750 ppm chlorides. The stress which this effluent places on the ecological conditions of the river should be assessed by a species diversity analysis. Water resources projects which reduce river flow in this region may cause this effluent to have an even greater impact.

Sulfates

The Texas Water Quality requirements for the Trinity River (FWPCA, 1969) limit sulfates to an average not to exceed 100 ppm. These limits are exceeded in a significant portion of the river basin. Beginning with Station 3, just below the Riverside Drive Sewage Treatment Plant in Fort Worth, Texas, the sulfate concentration exceeded 100 ppm at each station downstream to Station 9 on State Highway 85 near Kemp, Texas, with one high reading of 165 ppm being recorded at Station 8 at Rosser (Table 9). Station 10 at Cayuga, had an average of 84 ppm sulfate, but Station 11 downstream at U.S. Highway 79 near Elkhart exceeded this value with an average of 100 ppm.

Liefeste and Hughes (1967) reported that sulfate concentrations in their study were generally less than 50 ppm in tributaries in the basin, but the range in concentrations at Rosser was from 33 to 151 ppm and at Romayor from 24 to 60 ppm.

Forrest and Cotton (1970) reported that the Fort Worth Refining Company discharges 110 ppm sulfates in their discharges. American Cyanamid in the Dallas-Fort Worth area reported 1300 ppm sulfates in their effluents, and have a permit to discharge 166,800 pounds of sulfate per day. NIPAK, Incorporated, near Trinidad, Texas reports discharging 720 ppm sulfates in their effluent.

The increase of sulfates at Station 11 may be due to several sources above this station, with run-off from oil-fields probably being the major contributor. Chambers Creek, a tributary which receives oil-field run-off, contained concentrations of sulfates of 170 ppm. Saltwater Slough, a tributary near Station 11 which probably receives oil-field run-off, contained a concentration of 180 ppm sulfate. An additional source may be approximately five river miles upstream from Station 11. A mining operation for sandstone is adjacent to Blue Lake which is very near the Trinity River. The water from Blue Lake contained concentrations of 250 ppm sulfate and may contribute sulfur to the river by overflows or drainage.

All stations below Station 11 to Lake Livingston never exceeded 100 ppm sulfate and below the lake, the levels did not exceed 50 ppm. The effluents from Texas Gulf Sulfur, a mining industry near the Trinity River below Liberty, Texas contained 310 ppm sulfates. This effluent may place a stress on the biota in this portion of the river.

Population Survey of the Blue Crab, *Callinectes sapidus*

The Blue Crab, *Callinectes sapidus* Rathbun, appeared to be relatively abundant in the Trinity River up to Lake Livingston; however, no other species except the Blue Crab was captured. The Blue Crab, the most common crab on the Gulf Coast, migrate upstream from Trinity Bay and are probably prevented from further movement upstream by the dam at Livingston. No sampling was done above Lake Livingston. Leary (1961) reports that the Blue Crab has a high tolerance for changing water

conditions and can tolerate fresh water if the change from salt water to fresh water is made gradually by degrees.

Eighteen Blue Crab were caught at the station on Highway 59 near Livingston which is approximately 120 river miles from the coast. Nineteen specimen were captured at the bridge on Highway 105, ninety-five river miles from the coast.

One interesting point observed was the scarcity of females in the specimen caught. No females were caught at the Livingston station, one female was caught at Highway 105, and three females were caught at the station near Liberty. Many of the males caught were immature. The explanation of the sparseness of females may be due to the time in which the population was sampled. Leary (1961) reports that the peak of the spawning season is in June and early July, when the gulfward movement of the fertilized female crab is at its height. Collections were made in June and July, probably when the females had already migrated to the Gulf. Baldauf (1967) reported that the male Blue Crab may move farther upstream after mating. Tagatz (1965) reports that the males do not seem to be as strongly affected by spawning movements and seem to roam at will, often going far upstream.

The installation of barriers on the Trinity River near the coast will probably terminate the migration of Blue Crab upstream. Precisely what ecological impact this will have on the lower river is now only speculation. What type of interspecific competition exists between the Blue Crab and other scavenger organisms such as the crayfish? What organism might increase in numbers by the removal of the Blue Crab? How important is the Blue Crab in the aquatic food web in the lower river? These questions can only be answered after further investigation.

Pesticide Element

Mayhew (1972) reports that there were 250 reported fish kills in Texas during the past three years and sixty-seven percent of these kills could be traced directly to substances introduced by man's activities. Some of the substances that man appears to be discharging in ever-increasing quantities are insecticides and herbicides. Breidenback and Lichtenberg (1963) reported that in 1962 a sampling program of 101 stations revealed DDT in 32 samples from nine rivers in the United States. Schafer

(1969) reported that 40 percent of 500 samples of water collected from the Mississippi River contained Dieldrin.

An assessment of the insecticides and herbicides that are used within the counties in the watershed is probably a good indication of the amounts of pesticides polluting various regions of the river. Bailey and Hannum (1965) have presented data showing a high correlation between insecticide application and insecticide concentrations in river waters and sediments.

The northern regions of the river basin, with the exception of Chambers County near Trinity Bay, uses the greatest amounts of insecticides and herbicides (Tables 11, 12, and 13). Ellis, Kaufman, and Navarro counties in the northern part of the river basin, produce large acreages of cotton while Chambers County near the coast, is a major producer of rice. In the northern region of the study area the insecticides DDT, Toxaphene, and Carbaryl are probably the major contaminants while in the southern regions of the river, Carbofuran and Toxaphene are probably the most significant. Carbofuran (Furadan) is now being recommended by the Texas A&M University Agriculture Extension Service as the insecticide to control the rice water weevil, which is usually the most important insect pest on rice; however, some extension agents have recommended heptachlor for treatment.

According to U.S. Geological Survey data, the concentrations of pesticides and herbicides in the Trinity River are suitably low, but the concentrations in the river sediments may be considerably higher.

Bailey and Hannum (1965) report that pesticide concentrations in river waters decreased at a rate of about 0.0016 micrograms per liter per mile downstream from the points of application. The removal may in part be due to organism uptake, degradation of the molecule, or accumulation in the sediments. Bailey and Hannum have reported pesticide concentrations in river sediments exceeded those in water 20 to 100 times, with the concentrations being proportionately higher in fine sediments. Wharton (1970) reports that many pesticides, such as DDT have a high affinity for silt and would be trapped by sediments as silt is deposited.

Because many of the pesticide compounds are degraded very slowly in nature and because these compounds tend to become concentrated progressively at higher levels in the aquatic food chain, there should be concern from a public health point of view.

Table 11. Cumulative Acres Treated with Insecticides in Counties with the Trinity River Basin, from Dallas-Fort Worth Area to Trinity Bay, Texas, 1968-1971.

County and	Cumulative Acres Treated			
Crop	1968	1969	1970	1971
Anderson Co.				
Cotton	1500	1800	1227	-
Sorghum	-	200	4500	-
Field Corn	-	-	3000	-
Other Grain	-	-	20700	-
Forage Crops	-	8500	-	-
Fruits & Nuts	36	-	1200	-
Vegetable	5800	1600	12800	-
Chambers Co.				
Rice	-	-	-	31000
Ellis Co.				
Cotton	-	-	-	400000
Sorghum	-	-	-	10000
Oats	-	-	-	4000
Freestone Co.				
Cotton	-	600	1800	-
Sorghum	280	-	-	-
Field Corn	-	-	200	-
Other Grain	400	-	200	-
Forage Crops	350	-	4000	-
Fruits & Nuts	2000	3250	2800	-
Henderson Co.				
Cotton	100	300	300	-
Sorghum	1000	-	-	-
Field Corn	300	-	-	-
Wheat	0	500	-	-
Other Grain	0	-	-	-
Forage Crops	0	75000	7500	-
Fruits & Nuts	100	100	100	-
Vegetable	7500	5000	7000	-
Houston Co.				
Cotton	-	-	-	30000
Sorghum	-	-	-	8500
Oats	-	-	-	1500
Peanuts	-	-	-	8000

Table 11. continued

County and Crop	Cumulative Acres Treated 1968	1969	1970	1971
Kaufman Co.				
Cotton	-	-	-	100000
Sorghum	-	-	-	10000
Oats	-	-	-	9000
Leon Co.				
Cotton	-	-	-	8000
Vegetable	-	-	-	2000
Liberty Co.				
Cotton	-	-	-	4000
Rice	-	-	-	50000
Soybeans	-	-	-	30000
Navarro Co.				
Cotton	40000	40000	15100	-
Sorghum	17000	5000	10000	-
Wheat	-	1000	3000	-
Other Grain	400	5000	10000	-
Forage Crops	900	2500	10000	-
Fruits & Nuts	800	1000	-	-
Vegetable	500	500	1000	-
Polk Co.				
Sorghum	-	-	-	4000
Corn	-	-	-	50
Trinity Co.				
Sorghum	-	-	-	2300
Walker Co.				
Sorghum	-	-	-	2000

Table 12. Estimates of Insecticide Usage in the Trinity River Basin From Dallas-Fort Worth to Trinity Bay, Texas, 1968-1971.

Years	1968	1969	1970	1971
Anderson County				
Insecticides (total lbs. used)				
Carbaryl	4730	6581	23111	-
DDT	2250	2700	1840	-
Diazinon	580	160	1280	-
Guthion	37	-	1260	-
Malathion	1110	730	4313	-
Methyl parathion	328	393	643	-
Parathion	464	780	3990	-
Toxaphene	1875	2533	1533	-
Chambers County				
Insecticides (total lbs. used)				
Carbofuran	-	-	-	15500
Dallas County				
Insecticides (total lbs. used)				
no entries				
Ellis County				
Insecticides (total lbs. used)				
Carbaryl	-	-	-	1200
DDT	-	-	-	600000
Malathion	-	-	-	450
Parathion	-	-	-	1425
Toxaphene	-	-	-	400000
Freestone County				
Insecticides (total lbs. used)				
Carbaryl	8430	13256	14231	-
DDT	-	900	2700	-
Guthion	2100	3412	2940	-
Malathion	1305	2048	1974	-
Methyl parathion	-	131	418	-
Parathion	1708	2633	2583	-
Toxaphene	11	750	2383	-

Table 12. continued

Years	1968	1969	1970	1971
Henderson County				
<u>Insecticides</u> (total lbs. used)				
Carbaryl	6271	49352	10202	-
DDT	150	450	450	-
Diazinon	750	500	700	-
Guthion	105	105	105	-
Malathion	1494	4776	1751	-
Methyl parathion	59	65	65	-
Parathion	756	6119	1168	-
Toxaphene	125	2875	625	-
Houston County				
<u>Insecticides</u> (total lbs. used)				
Carbaryl	-	-	-	32850
DDT	-	-	-	45000
Malathion	-	-	-	7327
Parathion	-	-	-	16548
Toxaphene	-	-	-	30000
Kaufman County				
<u>Insecticides</u> (total lbs. used)				
Carbaryl	-	-	-	29700
DDT	-	-	-	150000
Malathion	-	-	-	5200
Parathion	-	-	-	8550
Toxaphene	-	-	-	100000
Leon County				
<u>Insecticides</u> (total lbs. used)				
Carbaryl	-	-	-	1500
DDT	-	-	-	12000
Diazinon	-	-	-	200
Malathion	-	-	-	375
Parathion	-	-	-	150
Toxaphene	-	-	-	8000

Table 12. continued

Years	1968	1969	1970	1971
Liberty County				
Insecticides (total lbs. used)				
Carbofuran	-	-	-	25000
DDT	-	-	-	6000
Toxaphene	-	-	-	94000
Navarro County				
Insecticides (total lbs. used)				
Carbaryl	10525	13975	28009	-
DDT	60000	60000	22650	-
Diazinon	50	50	100	-
Guthion	840	1050	-	-
Malathion	1088	706	2838	-
Methyl parthion	8750	8750	3303	-
Parathion	2696	2048	4800	-
Toxaphene	50030	50083	20041	-
Polk County				
Insecticides (total lbs. used)				
Carbaryl	-	-	-	37
Malathion	-	-	-	100
Methyl parathion	-	-	-	6
Parathion	-	-	-	450
San Jacinto County				
Insecticides (total lbs. used)				
no entries				
Trinity County				
Insecticides (total lbs. used)				
Malathion	-	-	-	57
Parathion	-	-	-	258

Table 12. continued

Years	1968	1969	1970	1971
Walker County				
Insecticides (total lbs. used)				
Malathion	-	-	-	50
Parathion	-	-	-	225

Table 13. Herbicide Usage in the Trinity River Basin From Dallas-Fort Worth to Trinity Bay, Texas 1970-1971

Counties	Total Gallons Used		
	2,4-dichlorophenoxy acetic acid		2,4,5-trichlorophenoxy acetic acid
	1970	1971	1971
Anderson	1622	-	-
Chambers	-	-	-
Dallas	-	288	0
Ellis	-	-	-
Freestone	782	-	-
Henderson	5100	-	-
Houston	-	6999	205
Kaufman	-	3104	0
Leon	-	6097	227
Liberty	-	-	-
Navarro	6529	-	-
Polk	-	1001	133
San Jacinto	-	0	0
Trinity	-	115	11
Walker	-	7831	1550

- No entries provided by Texas Department of Agriculture.

Based upon the estimated use of insecticides and herbicides in the study area, the northern portion of the river at Station 8 near Rosser, Texas, downstream to Station 11 at Highway 79 near Elkart and Station 19 near Wallisville, Texas should be problem areas warranting more study.

PROBLEM AREAS RECOMMENDED FOR IN-DEPTH STUDY

1. The region of the river between the Riverside Sewage Treatment Plant in Fort Worth, Texas to Loop 12 bridge in East Dallas is very critical because of the high quantity of municipal and industrial effluents being discharged into the river. The base flow of the river in this region appears to be sewage and is characterized by low or zero dissolved oxygen, high ammonia values and high total coliform populations.

2. The confluence of the East Fork Trinity northwest of Rosser (Highway 34) appears to be a critical region of the river. Not only is the water highly eutrophic with high nitrogen, phosphorus and BOD values, but the insecticide and herbicide usage in the counties adjacent to the river is very high. Significant pesticide pollution should be anticipated and studied.

3. The region of the river adjacent to NIPAK fertilizer plant, near Trinidad, Texas should be studied closely because of the nitrogen and phosphorus input.

4. Richland, Tehuacana, and Chambers creeks appear to be polluted with brine and the impact of these tributaries on the aquatic ecology of the Trinity River should be analyzed by a species diversity study.

5. The region of the river near Highway 84/79 appears to be critical because of the high phytoplankton populations, as well as very high nitrate and sulfate concentrations.

6. The region of the Trinity River from Highway 59 to Highway 90 near Liberty is significant because the water quality is relatively high and efforts should be made in future water resources projects to maintain that quality. Nutrient levels and total coliform bacteria populations are relatively low while the river apparently supports a diverse aquatic biota.

7. The Trinity River near Texas Gulf Sulfur Company appears to be a problem because of salt water and sulfur effluents, and the biological impact of this discharge should be studied by a species diversity analysis. Although there is some intrusion of salt water from Trinity Bay, especially during the months of low flow in the river, the intrusion problem should be ameliorated with the proposed dam at Wallisville, Texas. Because of the high amounts of pesticides used in the production of rice in Chambers County, insecticide and herbicide pollution should be anticipated and studied in this region of the river.

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CHAPTER IV

BOTANICAL ELEMENTS

by

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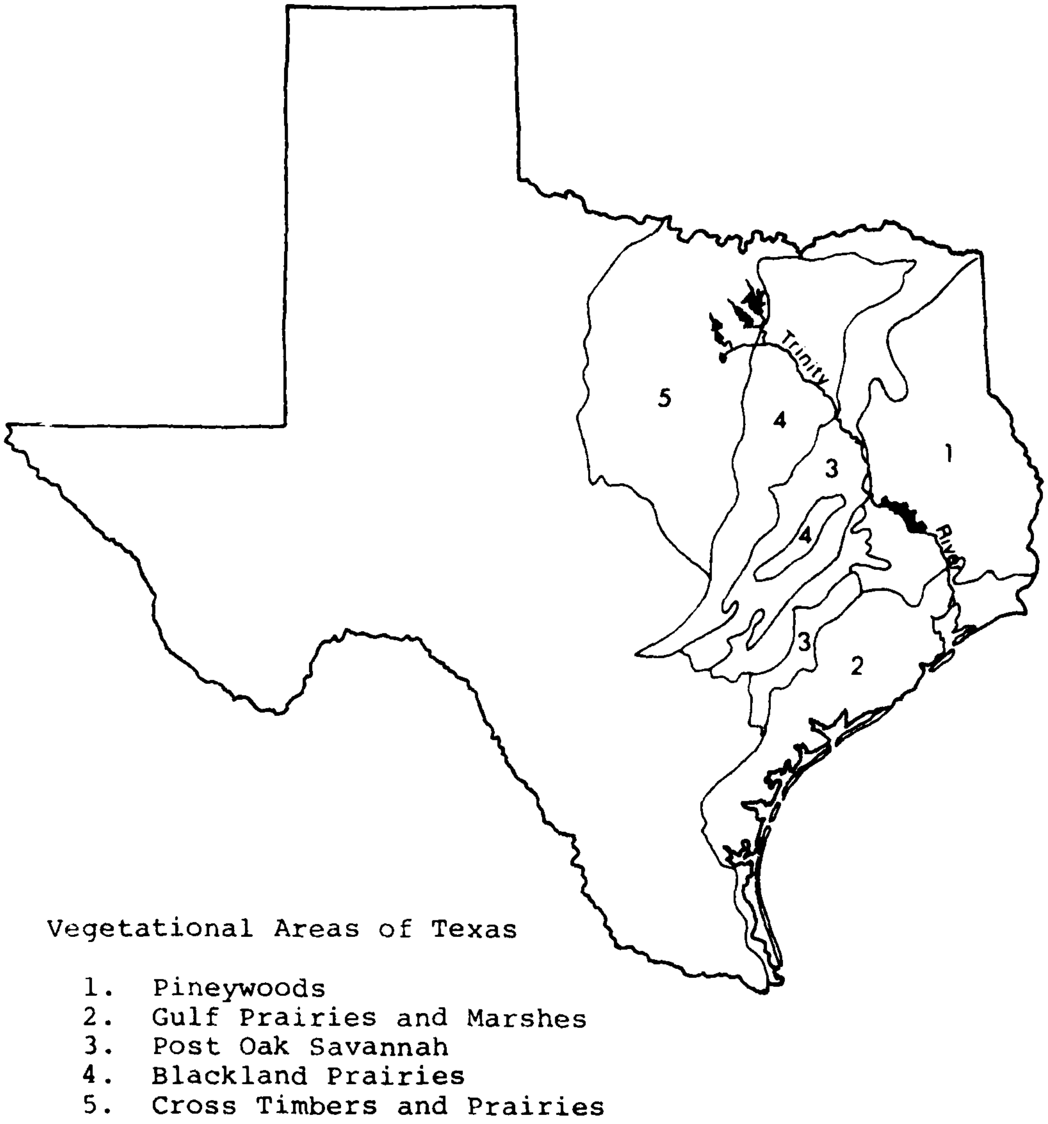
INTRODUCTION

The purpose of this study was to conduct a preliminary survey of the botanical elements (vascular plants) in association with the Trinity River Basin from Fort Worth to the upper reaches of the proposed Tennessee Colony Reservoir and from the damsite of the Tennessee Colony Reservoir to the upper reaches of the proposed Wallisville Reservoir. The vegetation in and around Lake Livingston was not included. The study focused upon the location of unique ecological areas which might merit future in-depth studies.

Many bottomland areas linked with large rivers have been cleared and converted to pasture and agricultural usage. Forest land bordering these rivers, in addition, has been lost to urbanization and to the development of country homes and sites. The Trinity River bottomlands are no exception. Bottomland areas associated with the river between Fort Worth and Lake Livingston have been greatly exploited. Hardwood forests are generally confined to rather narrow strips along the river, but in certain areas they become quite extensive. The vegetation, therefore, has been greatly modified, not only from the standpoint of timber loss, but also concerning the composition and relative abundance of both herbaceous and woody species.

Below Lake Livingston the general appearance and use of the Trinity River bottomland is noticeably different from that of above. Large scale farming begins to give way to timber growing and pasture utilization. The extensiveness of the forests is breath-taking and the occurrence of oxbow lakes and swamp areas creates a unique ecological diversity both from the standpoint of vegetation and habitat. Housing developments are occasionally encountered and become more profuse as one approaches the coastal cities.

Vegetatively, the Trinity River Basin is associated with several areas or types. Gould (1969) divides Texas into 10 vegetational areas. The Trinity River transects the pineywoods, Gulf Prairies and Marshes, Post Oak Savannah, Blackland Prairies and Cross Timbers and Prairies vegetational areas (Figure 20). Following



Vegetational Areas of Texas

1. Pineywoods
2. Gulf Prairies and Marshes
3. Post Oak Savannah
4. Blackland Prairies
5. Cross Timbers and Prairies

Figure 20. Map positioning the Trinity River in relation to surrounding vegetational areas. Vegetational areas after Gould, 1969.

are brief descriptions of these areas as generally characterized by Gould (1969).

The Trinity River, within the confines of this study, transects only a small portion of the Cross Timbers and Prairies area. The area is very variable from the standpoints of rainfall, soils and land use. The vegetation, however, is generally rather uniform. Predominant native grasses in the prairies are little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardi*), Indiangrass (*Sorghastrum avenaceum*), switchgrass (*Panicum virgatum*) and Canada wild-rye (*Elymus canadensis*). The Cross Timbers areas are dominated by trees such as post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) with herbaceous understory species including hairy tridens (*Erioneuron pilosum*) and Texas grama (*Bouteloua rigidiseta*).

The Blackland Prairies, under natural conditions, would be dominated by grasses such as little bluestem, big bluestem, switchgrass, Indiangrass and sideoats grama (*Bouteloua curtipendula*). The soils are generally dark-colored calcareous clays.

In general, the Post Oak Savannah vegetational area is characterized by the presence of upland trees such as post oak, blackjack oak and sandjack oak (*Quercus incana*) and of marginal bottomland species including southern red oak (*Quercus falcata*), white oak (*Quercus alba*), hickory (*Carya* spp.) and elm (*Ulmus* spp.) (Bray, 1906). The upland soils of the Post Oak Savannah area are light-colored, generally acid and are texturally classed as either sands or sandy loams. Bottomland soils are darker in color, acid, and range from sandy loams to clays.

The Pinewoods vegetation area is depicted by trees such as shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), post oak, blackjack oak, red oak, sweetgum (*Liquidambar styraciflua*) and black hickory (*Carya texana*) in the uplands and by overcup oak (*Quercus lyrata*), willow oak (*Quercus phellos*), Texas sugarberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*) and bush palmetto (*Sabal minor*) in the bottomlands (Tharp, 1926, 1939, 1952; Braun, 1950). The soils are usually light-colored, acid, and sands or sandy-loams.

The climax vegetation of the flat Gulf Prairies and Marshes area is largely grassland or post oak savannah. Tall bunch grasses such as big bluestem,

Indiangrass, eastern gamagrass (*Tripsacum dactyloides*) and gulf muhly (*Muhlenbergia capillaris* var. *filipes*) are characteristic. Soils are generally acid sands, sandy loams and clays.

Although the Trinity River is associated with the above vegetational areas, the vegetation type of great concern in this study was that of bottomland hardwood forests. Bottomland forests associated with the Sabine, Neches, Trinity and San Jacinto river systems occupy large areas and, as a result, have been classified by Bray (1906) and Collier (1964) as distinct vegetational types. These bottomland forests are considered to be westward extensions of hardwood forests typical of river bottom areas to the southeast (Bray, 1906; Braun, 1950).

METHODS AND PROCEDURES

A preliminary survey was made of the Trinity River bottomlands by vehicle, boat, and a helicopter flight to determine the presence of unique or interesting plant communities which might merit future in-depth study. These communities were initially analyzed by estimating the abundance and determining the kinds of shrub, woody vine and tree species present. The scale of estimate used was as follows:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

Dominance, therefore, when used in this study, is based upon estimated abundance. A checklist was prepared for woody vine, shrub and tree species encountered in this study. Nomenclature followed that of Correll and Johnston (1970).

Because of the magnitude of the Trinity River bottomland and the alloted time period (February, 1972 to August 1, 1972) each site was generally visited only once. Sites were studied by walking over as much of the area as possible. As a result of studying particular areas and of single visits to these areas, it is possible that some woody vine, shrub and tree species in the bottomland were not encountered.

In order to depict the plant communities of the Trinity River bottom on a more localized basis, the river was divided into segments. Each segment or area was mapped and plant communities were located and discussed. Tables reflecting composition and abundance of species were prepared for each area.

RESULTS

Area 1

The West Fork of the Trinity River extends from Fort Worth, Texas, to Dallas, Texas. That portion between Fort Worth and the Tarrant-Dallas county line subsumes Area 1 (Figure 21). This flat to gently rolling area has been greatly exploited leaving only small patches of forest generally less than 200 acres in size.

Cedar elm, green ash (Fraxinus pensylvanica), soap berry (Sapindus saponaria), American elm (Ulmus americana) and Texas sugarberry were dominant in this section of the river (Table 14). Black willow (Salix nigra) and cottonwood (Populus deltoides) were locally frequent and dominated some gravel pit areas. Existing sloughs were generally surrounded by swamp privet (Forestiera acuminata). The more prevalent understory woody species were coral berry (Symphoricarpos orbiculatus), poison ivy (Rhus toxicodendron) and green-briar (Smilax spp.) (Table 14).

There were no evident unique sites in this area of the Trinity River, although some large trees were present. Large trees of American elm, Texas sugarberry, pecan (Carya illinoinensis), cottonwood, green ash and bur oak (Quercus macrocarpa) were noticeable and were usually found close to the river. A wooded hilly area with openings and a spring present and located within the Post and Paddock Riding Club (Site 1, Figure 21), was somewhat unique due to a greater species and habitat diversity.

Area 2

From its beginning at the Tarrant-Dallas county line, Area 2 extends along the Trinity River to Interstate Highway 45 in the center of the city of Dallas (Figure 22). Forested areas are generally confined to the banks of the river, and as a result, estimates of abundance are restricted to riverside sites. The area has been greatly modified due to urban development.

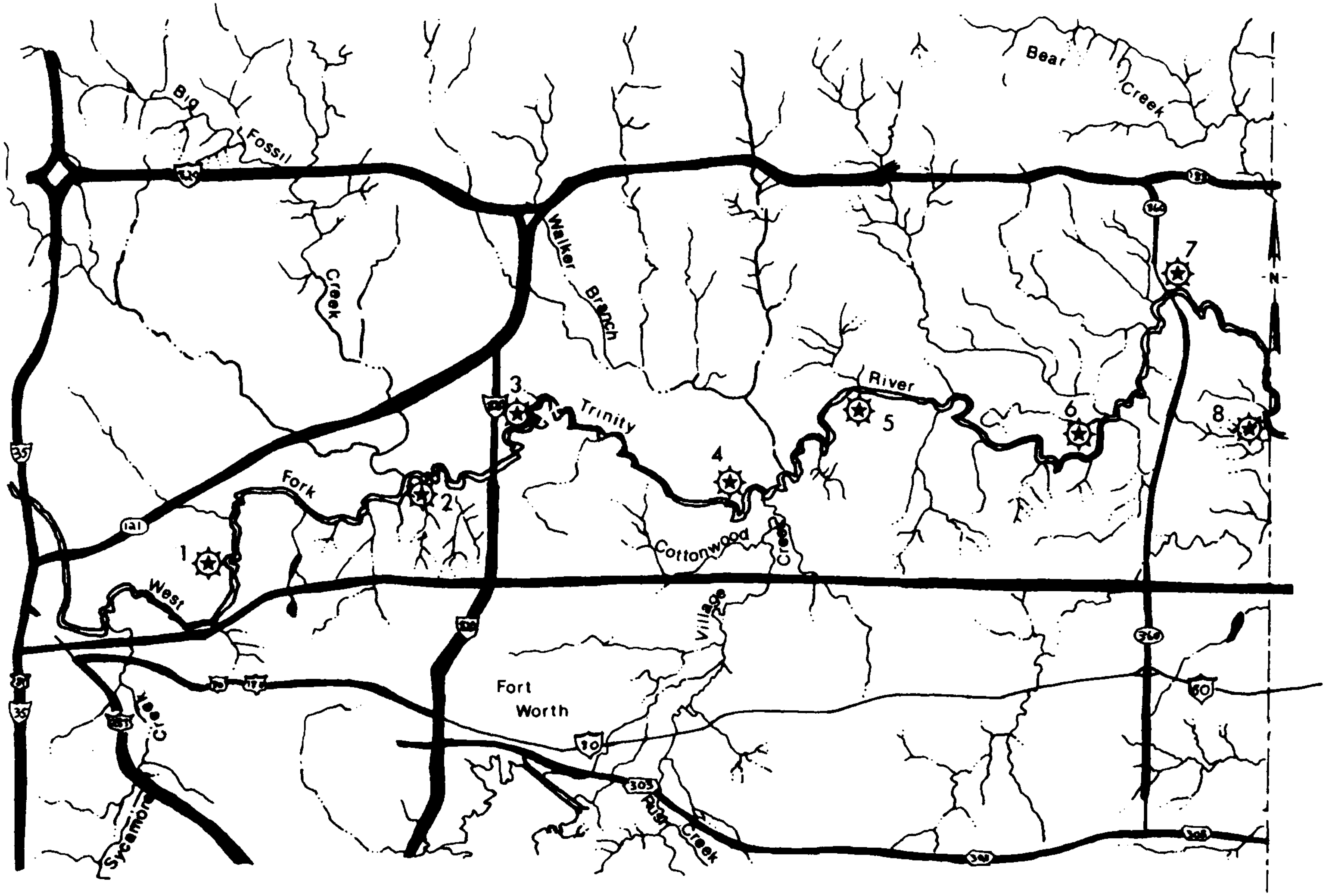


Figure 21. Trinity River Area 1 including Sites 1 through 8.

Table 14. Estimated abundance* of shrub, tree and woody vine species in Area 1 (See Figure 21).

	Sites Studied							
Species	1	2	3	4	5	6	7	8
Acer negundo	LO	LO	R-LO	R-LO	LO	R-LO	R-O	R-LO
Amorpha fruticosa.							R	
Aristolochia tomentosa		R	VR		R		R	VR
Baccharis neglecta			R	R			R-LO	
Bumelia lanuginosa	R	R-O	R	R-O	O	O	O	R-O
Campsis radicans	R	R-LO					R	
Carya illinoinensis.	O	R	R-O	R-LO	R-LO	R-O	O	R-O
Carya texana								O-LF
Celtis laevigata	O	F-LA	F	F-LA	A	F-A	F-A	F-LO
Celtis reticulata.								R
Cercis canadensis		R		R		R	R	R-LO
Cissis incisa.	R	R	R-O	R	R	R	R-O	R

Table 14. Continued

Species	Sites studied 1	2	3	4	5	6	7	8
Citrus trifoliata		R						
Cocculus carolinus.	R-O	R	R	R		R	R	R
Cornus drummondii		R-LO	R		R-LO	R	R-LO	O
Crataegus brazoria.						R		
Crataegus glabriuscula				O		R-LO		
Crataegus mollis.				O		R		
Crataegus sp.	R-O	R-O	O		O-LF		O-LF	R-O
Cucurbita foetidissima. . . .			R		R			
Diospyros virginiana.								R
Euonymus atropurpureus. . . .								R
Forestiera acuminata.	LA	R-O	LA	R-LO	LF	LF	LF	F-LF
Fraxinus americana.			R	R				
Fraxinus pensylvanica	LO	LO	O-F	O	O	R-LO	O-LF	LO

Table 14. Continued

Species	Sites studied 1	2	3	4	5	6	7	8
Gleditsia triacanthos	R	R	R-O		R-LO	R-O	R-O	R-O
Ilex decidua	R	R-O	R	R	R-LO	R-LO	R	LO
Juniperus virginiana						VR	R	R-O
Ligustrum quihoui		R		R				
Ligustrum sp.	R	R	R				VR	
Maclura pomifera	R	R-LO	O	O	R	R		R-O
Matelea gonocarpa	R	R	R	R	R	R	R-O	R
Melia azedarach	R-O	R-O	R	R	R		R	
Melothria pendula	R	R	R		R	R		VR
Morus alba	R		R					
Morus rubra	O	O-LF	O	R-O	R-O	R-O	O	R-O
Parkinsonia aculeata		VR						
Parthenocissis quinquefolia	O	R-O	O	R	R-O	R-O	O	R-O

Table 14. Continued

Species	Sites studied							
	1	2	3	4	5	6	7	8
Passiflora incarnatum				R				
Phoradendron sp.				R		R		
Platanus occidentalis	R	R					R	R
Populus deltoides	LO	LO	LO	LO-LA	LO		LO-LF	LO
Prosopis glandulosa		R	R	R	VR	LO-LF	R-LO	LO
Prunus mexicana				VR			R-LO	R-LO
Prunus persica			VR					
Ptelea trifoliata		R						
Quercus macrocarpa		O	O	R-O	O	O	R-O	R-O
Quercus marilandica						R		R-LO
Quercus shumardii		R	R	R	R	R	R	R-LO
Quercus stellata						LO	LO	LF
Quercus texana								R

Table 14. Continued

Species	Sites studied 1	2	3	4	5	6	7	8
Rhus aromatica							R-LO	
Rhus glabra.							R	R-LF
Rhus toxicodendron	R-O	R	R-O	R-O	R-O	R	O	O
Rubus sp..	R	R-LO		R-LO		R	R	
Salix nigra.	LO	LO	LO	LO	LO	LO	LO	LO
Sambucus canadensis.	LF	LF	LF	R	R		R	R-LF
Sapindus saponaria	O	O	F	R-LF	F	F	O-F	R-O
Smilax bona-nox.	O-F	F-A	O	F-LA	F	O-F	F	F
Smilax hispida								R
Smilax rotundifolia.	R	R-O	O	LO	R	R	R	R-O
Solanum triquetrum								R
Sophora affinis.	R-O	R	R-O	R-O	R-O	O-F	O	R-LO
Symphoricarpus orbiculatus . . .	O-LF	F	F	F	O	LF	O-LF	O

Table 14. Continued

Species	Sites studied							
	1	2	3	4	5	6	7	8
Tilia americana			R					
Ulmus alata								R-LF
Ulmus americana	O-LF	LO	O	R-LF	O	R-LO	O-F	O-F
Ulmus crassifolia	O-LA	F-LA	F	F-LA	F-A	F-A	F-A	F-LA
Viburnum rufidulum		R			R	R-LO	VR	LO
Vitex agnus-castus		R		VR				
Vitis aestivalis	LO						R-O	
Vitis mustangensis								R-O
Vitis rotundifolia			R	R	R			R-O
Zanthoxylum clava-herculis		VR		R	VR	R		O-LF

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

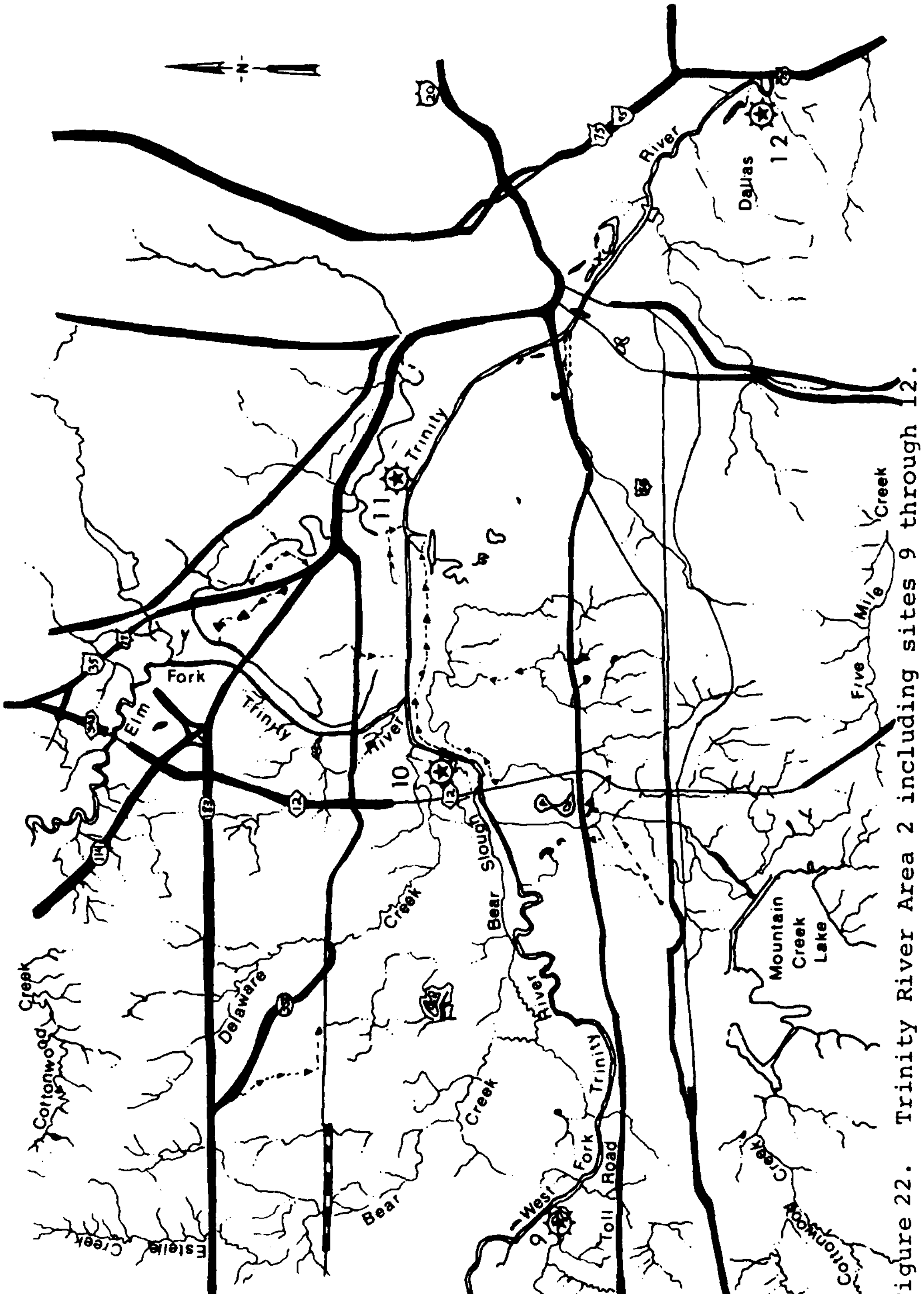


Figure 22. Trinity River Area 2 including sites 9 through 12.

Black willow and eastern cottonwood were generally frequent along the Trinity River and at times were abundant in wet, low-lying areas. Green ash, soapberry, Texas sugarberry and cedar elm were locally prevalent (Table 15).

Unique vegetational areas were absent. An area of about 50 acres near Interstate Highway 45, however, had an uncommon abundance of red mulberry (*Morus rubra*).

Area 3

Area 3 lies within Dallas County between Interstate Highway 45 and Mallow Bridge Road (Figure 23). Larger and somewhat less disturbed tracts of forest were present, but were generally situated between the flood control levees of the river.

Dominant tree species along this section of the river were Texas sugarberry, green ash and cedar elm (Table 16). Large trees were scarce, probably as a result of past selective cutting. Some sites, however, have more recently been protected by hunting and fishing clubs. The most unique area in this section of the river was that associated with the Fin and Feather hunting and fishing club because of species and habitat diversity (Site 14, Figure 23). This site included approximately 1000 acres of forest and contained several lakes and ponds which displayed a varied herbaceous flora. Woody plants of green ash, buttonbush (*Cephalanthus occidentalis*) and black willow frequented the margins of these lakes and ponds. Site 15 (Figure 23) is aesthetically pleasing due to the presence of a natural cut-off of about 30 acres in size, but vegetatively it is similar to other forests in this sector.

Area 4

Area 4 extends from the Mallow Bridge Road in Dallas County to just south of State Highway 34 in Ellis and Kaufman counties (Figure 24). Agriculture is the major land use along this sector of the river, and most of the land outside of the protective levees is cleared. Forests are confined to rather narrow bands between the levees except in the area around the junction of the East Fork of the Trinity River. Numerous sloughs are scattered throughout area 4. The trees were generally small to medium in size. Past selective logging was evident.

Table 15. Estimated abundance* of shrub, tree and woody vine species in Area 2 (See Figure 22).

Species	Sites studied 9	10	11	12
Acer negundo	R-O	R-LO	O-F	O-F
Amorpha fruticosa		R-LO	R-O	
Baccharis neglecta		R		
Berchemia scandens				R-O
Bumelia lanuginosa	R	O	R	R
Campsis radicans				R-O
Carya illinoinensis	R-O	O-LF	R	O-LF
Catalpa speciosa				VR
Celtis laevigata	A	F-A	O	F-A
Cephalanthus occidentalis		R		VR
Cercis canadensis			VR	R
Cissis incisa		R		
Cocculus carolinus				R-O
Cornus drummondii				VR
Crataegus sp.	O-F	R-O		
Diospyros virginiana				R
Forestiera acuminata	LA	F-LF	O	F-LF
Fraxinus pensylvanica	O	F	O-F	F
Gleditsia triacanthos	R-O	O-LF	R	R-O

Table 15. Continued

Species	Sites studied 9	10	11	12
Ilex decidua		R		
Juniperus virginiana		R	R	VR
Ligustrum sp.	R		R-O	
Ligustrum sp.			R	
Maclura pomifera	O	O	R-O	F
Matelea gonocarpa	R			
Melia azedarach	R	R-O	R	O
Morus alba		R	R-O	
Morus rubra	R-O	R-O	O	LA
Parthenocissis quinquefolia		R	R	
Platanus occidentalis				R
Populus deltoides	LO	LF-LA	A	F-A
Prosopis glandulosa	R-O	R-O	R	
Quercus macrocarpa	R	R		
Quercus shumardii				R
Rhus toxicodendron	O	O		F
Rubus trivialis		R-LO		
Rubus sp.			LO	O
Salix nigra	LF	LF-LA	A	F-A
Sapindus saponaria	O-LF	F	O-LF	F
Smilax bona-nox	F	O-LF	O	O
Smilax rotundifolia	F	O-F	R-O	

Table 15. Continued

Species	Sites studied 9	10	11	12
Sophora affinis	R-O	O-F	R-LF	R-O
Symphoricarpus orbiculatus	LO	R-LO		R
Tamarix gallica		R		
Ulmus americana	O	O	R	O
Ulmus crassifolia	A	F-A	O	R
Vitex agnus-castus			R	LO
Vitis mustangensis		R-O		
Vitis rotundifolia	R			
Vitis sp.				R-O
Zanthoxylum clava-herculis		R		

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

Figure 23. Trinity River Area 3 including Sites 13 through 15.

Table 16. Estimated abundance* of shrub, tree, and woody vine species in Area 3 (See Figure 23).

Species	Sites studied 13	14	15
Acer negundo	O-F	LO	F
Ampelopsis arborea	R-O	O	R
Ampelopsis cordata	R		
Berchemia scandens		R	VR
Brunnichia ovata			R
Bumelia lanuginosa	R	VR	VR
Callicarpa americana		LO	
Carya illinoinensis.	R	R-LO	R-LF
Catalpa speciosa		VR	VR
Celtis laevigata	A	F	F
Cephalantus occidentalis . .		LF	R
Cercis canadensis.		R	
Cissis incisa.		R	
Cocculus carolinus	O	R	O
Cornus drummondii.		O	F
Crataegus glabriuscula . . .			VR
Crataegus marshallii		R-O	
Crataegus viridis.	O		VR
Crataegus sp..		R	

Table 16. Continued

Species	Sites studied 13	 14	 15
Diospyros virginiana		R	R
Forestiera acuminata	O-LA	LA	LF
Fraxinus americana		R	
Fraxinus pensylvanica	F	F	F
Gleditsia triacanthos	R-O	R	VR
Ilex decidua		O-LF	R-O
Juniperus virginiana		R	
Lonicera japonica		R	
Maclura pomifera	F	R-O	R-LO
Matelea gonocarpa	R	R	VR
Melia azedarach		R	
Melothria pendula	R		
Morus rubra	O-F	R-O	O-F
Parthenocissus quinquefolia .	R-O	O-F	F-A
Passiflora incarnata	R		R
Platanus occidentalis	R	R	R
Populus deltoides		LF	LO
Prunus augustifolia		R	
Quercus macrocarpa	R	R	R
Quercus shumardii		R-O	R
Quercus stellata		R	
Rhus glabra	LO		R

Table 16. Continued

Species	Sites studied 13	 14	 15
Rhus toxicodendron	F	R-O	LF
Rubus sp..	LA	R-LO	O-LA
Salix nigra.	R-LF	LF	LO
Sambucus canadensis.		LO	F-LA
Sapindus saponaria	O-F	O	O
Smilax bona-nox.	F	O	F
Smilax hispida			R
Smilax rotundifolia.	F	R-O	R-O
Solanum triquetrum			LO
Sophora affinis.	R-O	R-O	R-O
Symphoricarpus orbiculatus .		R-LO	VR
Ulmus alata.		R	
Ulmus americana.	R-O	O	O-F
Ulmus crassifolia.	F-A	F	O-F
Viburnum rufidulum		R	
Vitex agnus-castus		VR	
Vitis cinera	R-O		
Vitis mustangensis	R-O	LO	R
Vitis riparia.			R
Vitis rotundifolia			R-O
Zanthoxylum clava-herculis .		R	

Table 16. Continued

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*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

The most frequently encountered woody species were Texas sugarberry, swamp privet, cedar elm and poison ivy. The forested area of Site 17 (Figure 24) was noteworthy from the standpoint of area covered, approximately 1300 acres, but was not noticeably different in species composition or general habitat.

Prevalent species along this sector of the river were Texas sugarberry, swamp privet, green ash, poison ivy and cedar elm (Table 17).

Area 5

The Trinity River bottom area between State Highways 34 and 85 represents Area 5 (Figure 25). This area is generally farmed with an occasional large tract of forest. Site 19 (Figure 25), which contains approximately 1900 acres of forested area, is somewhat interesting due to the occurrence of a slough which transects most of the site. Logging, however, has been extensive resulting in a fairly monotone forest of cedar elm, green ash and swamp privet. Green briar (mostly Smilax bona-nox) was uniformly prevalent. Pecan trees were locally frequent in the northwest portion of the forest near Walker Creek. Site 20 (Figure 25) with about 400 acres of forest was comparable to Site 19 in species composition and abundance with the exception of a slight increase in occurrence of green ash.(Table 18).

Proposed Tennessee Colony Reservoir Site

The area along the Trinity River between Highways 85 and 84-79 was previously inventoried by Stephen F. Austin State University (1972) (See Appendix C, Botanical Elements, by E. S. Nixon). Reference can be made to this study for occurrence of unique botanical areas and abundance of woody species within this section of the river.

Area 6

Area 6 lies between Highway 79-84 and the Navarro Oil Field north of the Shiloh Church Community in Leon County (Figure 26). This section of the river is flat to gently rolling. Most of the land has been cleared for crops and pastures, but wooded strips have been left along the margins of the river. One fairly extensive forest of approximately 2200 acres is located

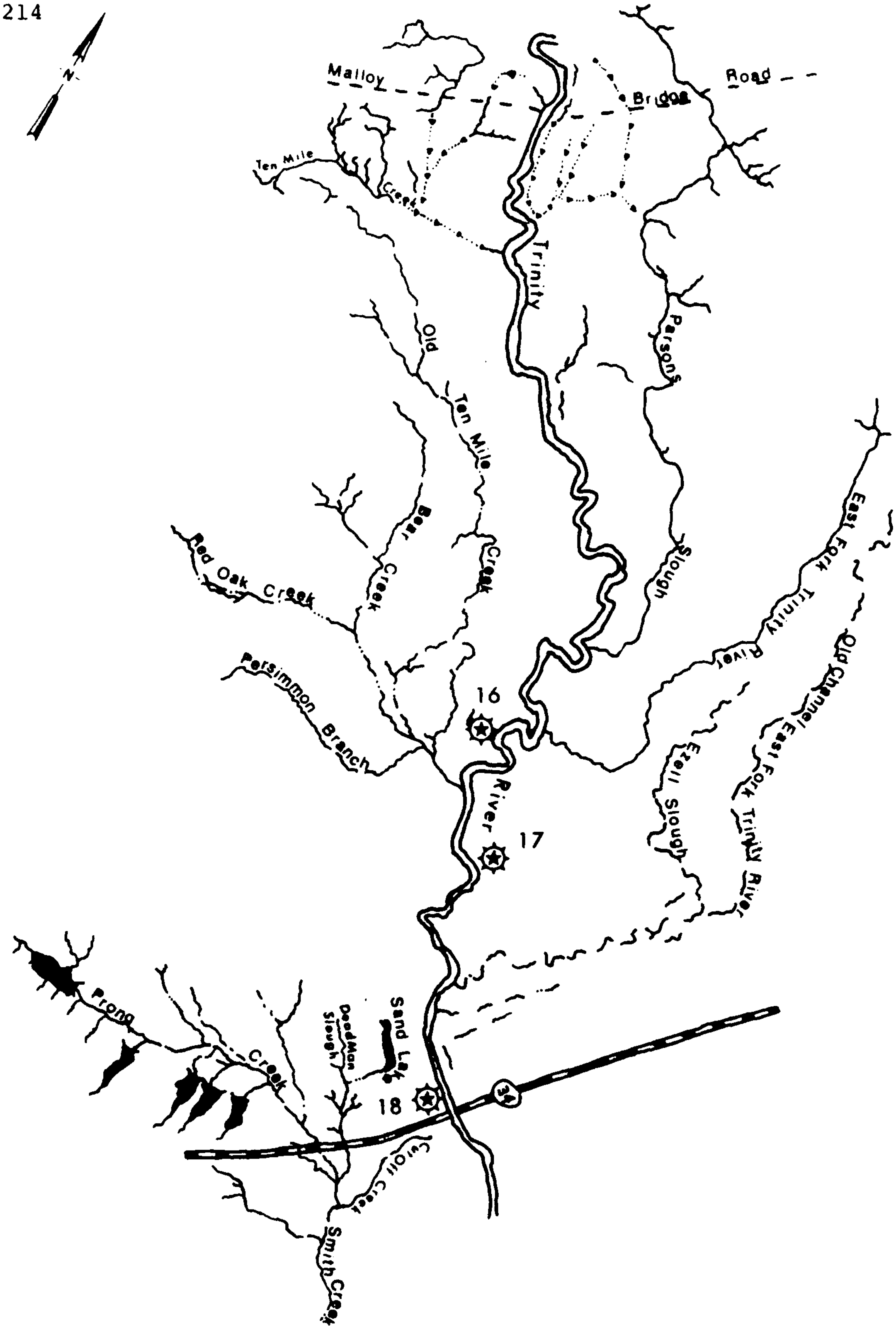

Figure 24. Trinity River area 4, including sites 16 through 18.

Table 17. Estimated abundance* of shrub, tree, and woody vine species in Area 4 (See Figure 24).

	Sites studied		
Species	16	17	18
Acer negundo	LO-LF	O	LO
Ampelopsis arborea	LF	R-LO	LF
Bumelia lanuginosa	R	R	R
Campsis radicans		R-LO	R-O
Carya illinoinensis	R	R	R-LO
Celtis laevigata	F-A	F-LA	F-LA
Cephalanthus occidentalis	R	R	LO
Cercis canadensis	VR		VR
Cissus incisa			VR
Cocculus carolinus	R-O	R	R-O
Cornus drummondii	O-LF	R-O	O
Crataegus sp.		R	R
Diospyros virginiana	R		R
Forestiera acuminata	LF	LF	LF
Fraxinus pensylvanica	F	F	F
Gleditsia triacanthos	R	R	R
Ilex decidua	O-F	O-LF	R-O
Juniperus virginiana	VR		
Maclura pomifera	R-O	R	R-O

Table 17. Continued

Species	Sites studied 16	17	18
Matelea gonocarpa		R	R
Morus rubra	O-LF	O	R-O
Parthenocissis quinquefolia .	F	R-O	O
Passiflora incarnatum			R
Passiflora lutea.	VR		
Populus deltoides	R-LO	LO	LO
Quercus macrocarpa.	R	R	R-O
Quercus nigra			VR
Quercus shumardii	R-O	R	R
Quercus stellata.			VR
Rhus glabra			R
Rhus toxicodendron.	O	F-LA	F-LA
Rubus sp.	LO	LF	LO
Salix nigra	LO	LO	LO
Sambucus canadensis	O-LA		
Sapindus saponaria.	O-LF	O	O
Smilax bona-nox	O	R-O	LF
Smilax rotundifolia	R-O	R	R
Sophora affinis	R-O	R-O	R-O
Symphoricarpus orbiculatus. .	R		VR
Ulmus americana	O-F	R-O	LO
Ulmus crassifolia	F	O-LF	F

Table 17. Continued

Species	Sites studied 16	17	18
Viburnum rufidulum	R		VR
Vitis mustangensis	R-O	R	R
Vitis palmata	R		
Vitis rotundifolia	R-O	R	

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

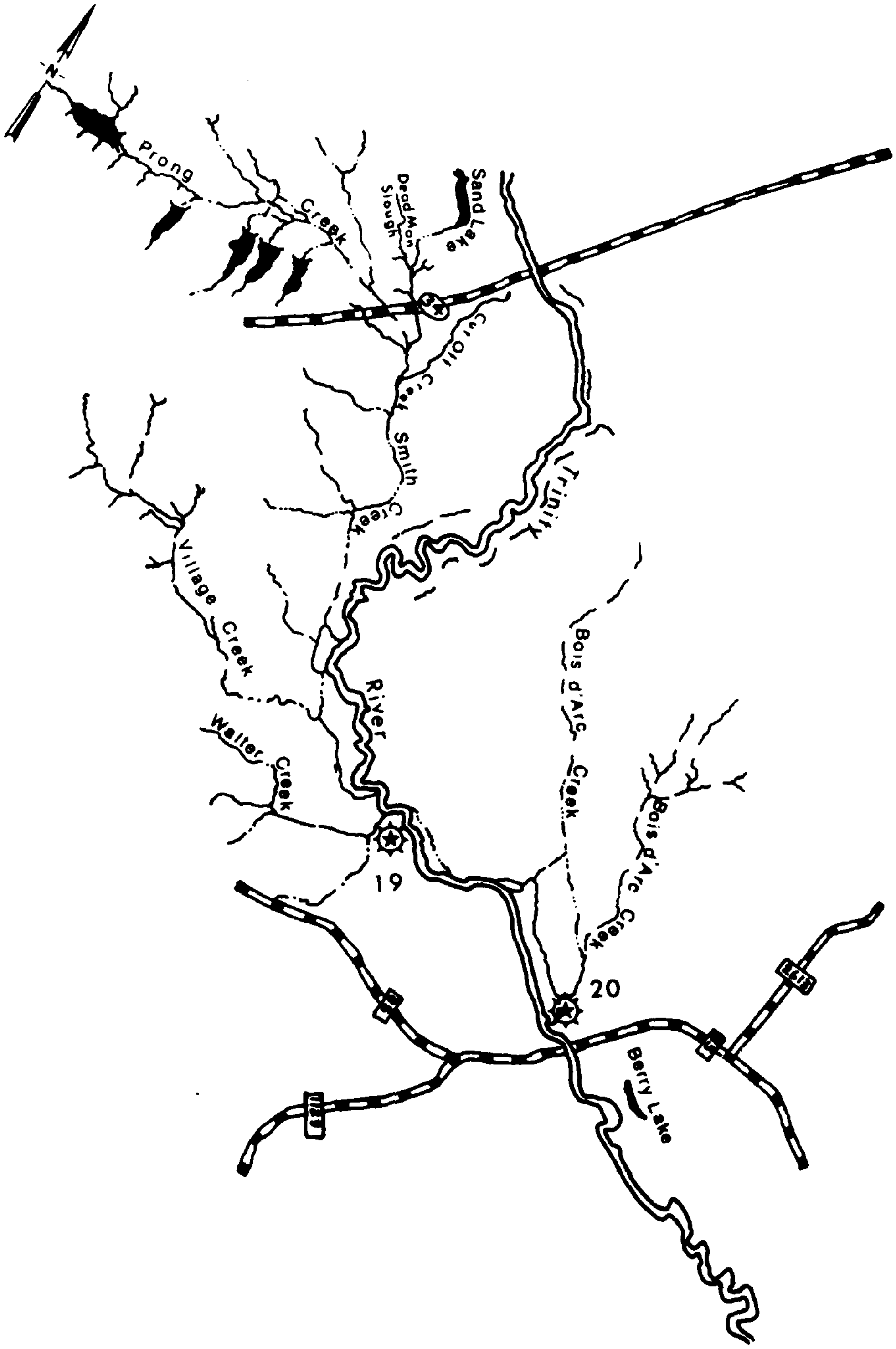

Figure 25. Trinity River Area 5, including Sites 19 and 20.

Table 18. Estimated abundance* of shrub, tree, and woody vine species in Area 5 (See Figure 25).

Species	Sites studied 19	20
Acer negundo	R	R-LO
Amorpha fruticosa.	VR	
Ampelopsis arborea		LO
Berchemia scandens		VR
Bumelia lanuginosa	R	R-O
Campsis radicans	O	R
Carya illinoinensis.	R-LO	R
Celtis laevigata	O	O
Cercis canadensis.	VR	
Cocculus carolinus	R	R
Cornus drummondii.	R-LO	
Crataegus sp..	R	R-O
Diospyros virginiana		R
Forestiera acuminata	F-LA	F-LA
Fraxinus pensylvanica.	O	O-F
Gleditsia triacanthos.	R-O	R
Ilex decidua	R	R
Maclura pomifera	R	R-O
Matelea gonocarpa.	VR	

Table 18. Continued

Species	Sites studied 19	 20
Morus rubra	R	R
Parthenocissis quinquefolia	R	
Populus deltoides	R	
Quercus shumardii	R	
Rhus toxicodendron	O	O
Rubus sp.	R-LO	LO
Sabal minor		VR
Salix nigra	LO	LO
Sambucus canadensis	R-LO	
Sapindus saponaria	LO	R-O
Smilax bona-nox	F	F
Smilax rotundifolia	R	R-O
Sophora affinis	R	
Ulmus americana	R	R
Ulmus crassifolia	F-LA	F
Vitis rotundifolia	R	R

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

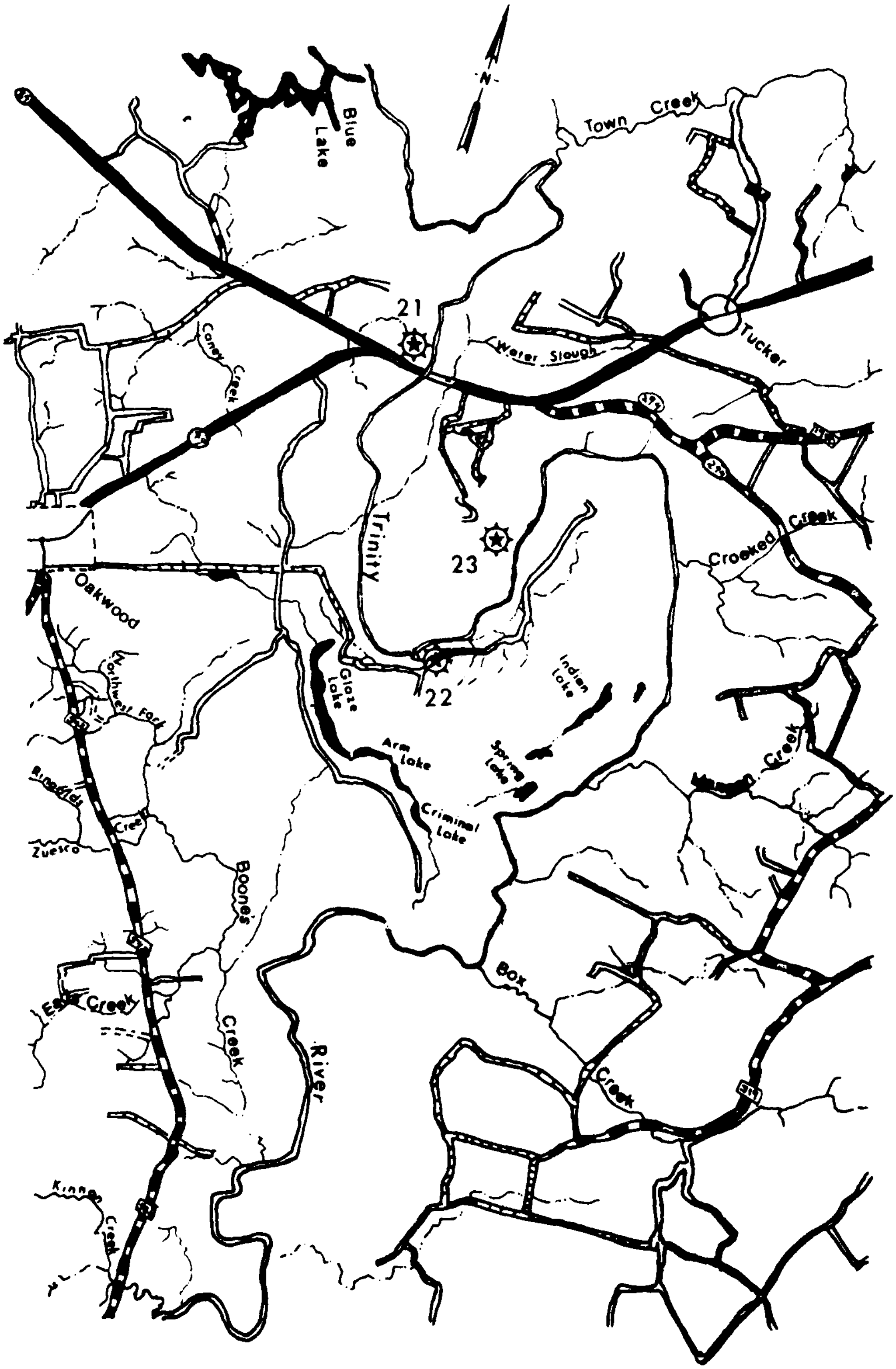

Figure 26. Trinity River Area 6, including Sites 21 through 23.

within the first large bend of the river below Highway 79-84 (Site 23, Figure 26). The area has been logged within the past few years and there are many large openings in the forest canopy. The major species, based on abundance, were black willow (along the river), swamp privet (poorly drained areas), poison ivy and cedar elm (Table 19). Red mulberry, which was only rare to occasional along this sector of the river, was very abundant at Site 23 (Figure 26). Woody species within Site 22 (Figure 26) were marginally located along the river. The area was open resulting in a more diverse herbaceous flora. One old homesite area displayed an unusual abundance of black walnut (*Juglans nigra*).

Area 7

The area represented by Figure 27 lies between a point west of the St. Paul Shiloh School in Leon County and a point just below the junction of the Trinity River and Beaver Dam Creek south of State Highway 7. The major emphasis in land use is agriculture. A large part of the land along this sector has been cleared, resulting in bands of wooded areas along the river. These border strips have often been partially cleared, leaving pecan or other selected trees to form wooded pasture land. The larger blocks of forest (e.g., Site 24, about 900 acres) are also grazed. The canopies are not dense, undergrowth varies from open areas to dense thickets, and the larger and more commercially desirable trees have been logged. Black willow is the dominant species along the river, with swamp privet forming dense colonies on poorly drained sites. Other generally abundant species along this section of the river were peppervine (*Ampelopsis arborea*), green ash, honey locust (*Gleditsia triacanthos*) and poison ivy (Table 20).

Area 8

Area 8 extends from near the junction of Beaver Dam Creek and the Trinity River just south of State Highway 7 to just below the junction of the Trinity River and State Highway 21 (Figure 28). The terrain is flat to gently rolling. Agriculture is the major land use and much of the river is bordered by large ranches which have been cleared for pasture and crop production. Bands of trees extend along the river in most places with larger blocks of forest occasionally present. The most abundant woody species were cedar elm, honey locust, poison ivy and black willow (Table 21).

Table 19. Estimated abundance* of shrub, tree, and woody vine species in Area 6 (See Figure 26).

	Sites studied		
Species	21	22	23
Acer negundo		F	F
Ampelopsis arborea	F	A	O
Berchemia scandens			O
Bumelia lanuginosa		R	
Campsis radicans		O	O
Carya aquatica			VR
Carya cordiformis		O	
Carya illinoinensis			R
Carya texana		R	
Carya tomentosa		O	
Celtis laevigata	O	O	F
Cercis canadensis		LA	
Cornus drummondii		O	LF
Crataegus spathulata			O
Crataegus sp.			O
Diospyros virginiana		F	
Forestiera acuminata	A		LD
Fraxinus pensylvanica	F		F
Gleditsia aquatica	OF		

Table 19. Continued

Species	Sites studied 21	22	23
Gleditsia triacanthos		R	O
Ilex decidua		R	F
Ilex vomitoria			O
Junglans nigra		A	VR
Juniperus virginiana		O	
Maclura pomifera		LA	
Melia azedarach		R	
Morus rubra			A
Parthenocissus quinquefolia			O
Pinus taeda		VR	
Platanus occidentalis		O	
Populus deltoides	A	R	
Quercus falcata		O	
Quercus lyrata.	R		O
Quercus macrocarpa		O	O
Quercus marilandica		O	
Quercus nigra		R	
Quercus phellos		R	F
Quercus shumardii		R	
Quercus stellata		R	
Rhus copallina		O	
Rhus toxicodendron	O	A	D

Table 19. Continued

Species	Sites studied 21	22	23
Rubus sp.	O		
Salix nigra	A	LA	LD
Sapindus saponaria		O	O
Sassafras albidum		LA	
Smilax bona-nox			O
Sophora affinis		LA	
Symphoricarpus orbiculatus		O	
Ulmus alata		R	
Ulmus americana		O	
Ulmus crassifolia	A		F-A
Ulmus rubra			R
Viburnum rufidulum		R	
Vitis cinerea		O	
Vitis mustangensis	A	O	O
Vitis vulpina	A		
Zanthoxylum clava-herculis		O	

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

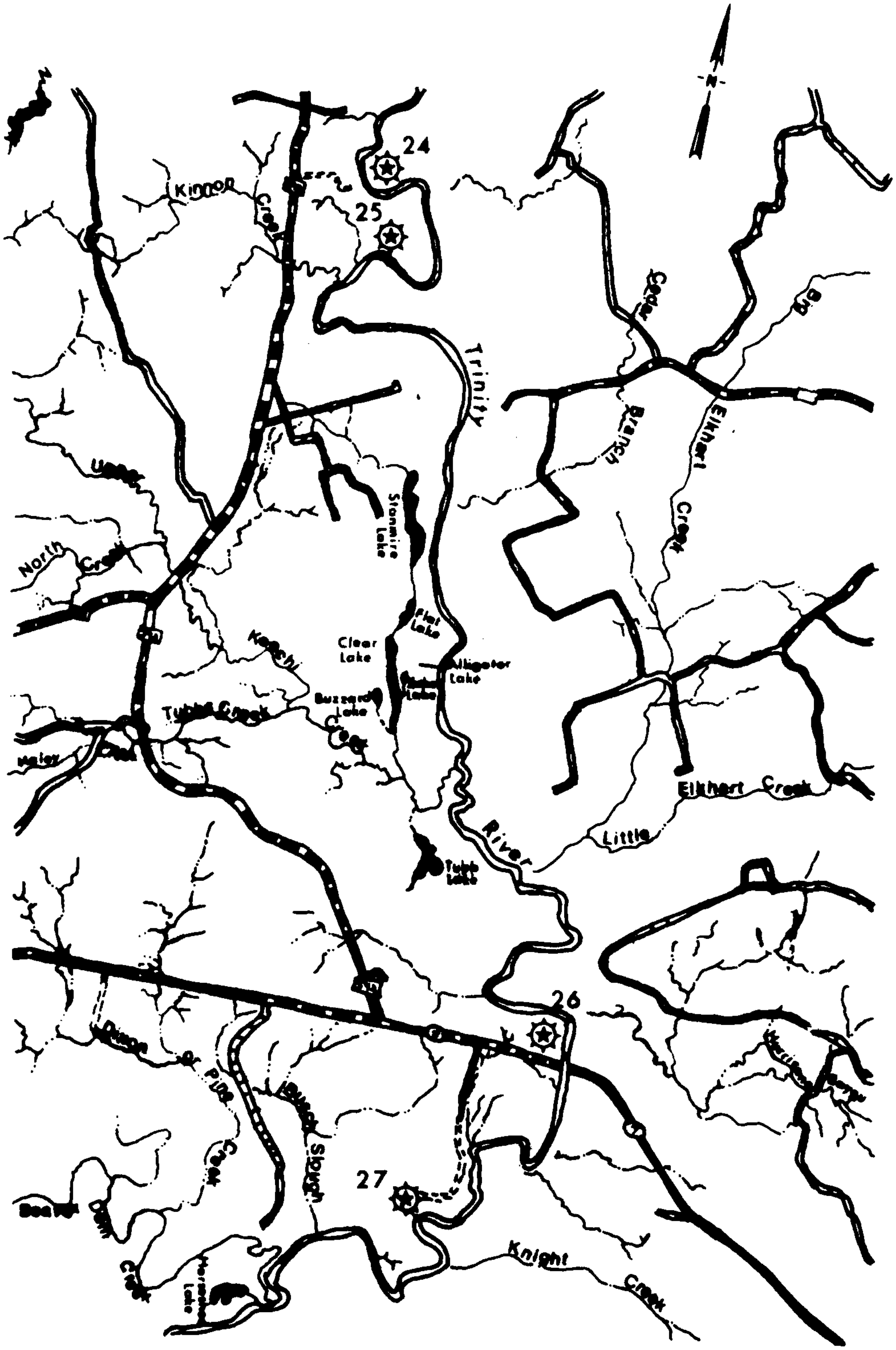

Figure 27. Trinity River Area 7,including Sites 24 through 27.

Table 20. Estimated abundance* of shrub, tree, and woody vine species in Area 7 (See Figure 27).

Species	Sites studied 24	25	26	27
Acer negundo		R	LO	
Ampelopsis arborea	A	A	LD	O
Berchemia scandens			LA	O
Bumelia lanuginosa	LF		R	
Campsis radicans			O	
Carya aquatica	R	O	O	F
Carya illinoinensis	O	D	F	O
Celtis laevigata	F	F	A	F
Cephalanthus occidentalis			R	
Cercis canadensis			A	O
Cornus drummondii			A	O
Crataegus spathulata	O	O		
Crataegus sp.	A	O		LD
Diospyros virginiana			LA	A
Forestiera acuminata	F	LA	F	LD
Fraxinus americana			LA	R
Fraxinus pensylvanica	F	O	A	O
Gleditsia triacanthos	F	F	A	F
Ilex decidua	O		LO	F

Table 20. Continued

Species	Sites studied			
	24	25	26	27
Ilex vomitoria			O	
Liquidambar styraciflua				LA
Maclura pomifera			R	
Melia azedarach			LF	
Morus rubra			R	O
Parthenocissus quinquefolia			O	
Platanus occidentalis	F	O	R	LF
Populus deltoides			LA	LD
Quercus falcata				R
Quercus lyrata	O		O	O
Quercus macrocarpa		O	R	
Quercus nigra			LA	F
Quercus phellos				O
Quercus prinus			O	
Quercus shumardii			F	
Quercus stellata			O	
Rhus toxicodendron	A	A	A	A
Rubus sp.			LA	
Sabal minor	R	R	R	O
Salix nigra	F	LD	F	LD
Sambucus canadensis			R	
Sapindus saponaria			O	

Table 20. Continued

Species	Sites studied 24	25	26	27
Smilax bona-nox	F		F	O
Smilax rotundifolia			F	O
Tilia americana	R		LF	
Ulmus alata			LD	
Ulmus americana	R		F	
Ulmus crassifolia	F		F	D
Vitis mustangensis				F
Vitis rotundifolia	O		F	O
Vitis sp.			F	

*Abundance is based upon the following scale:

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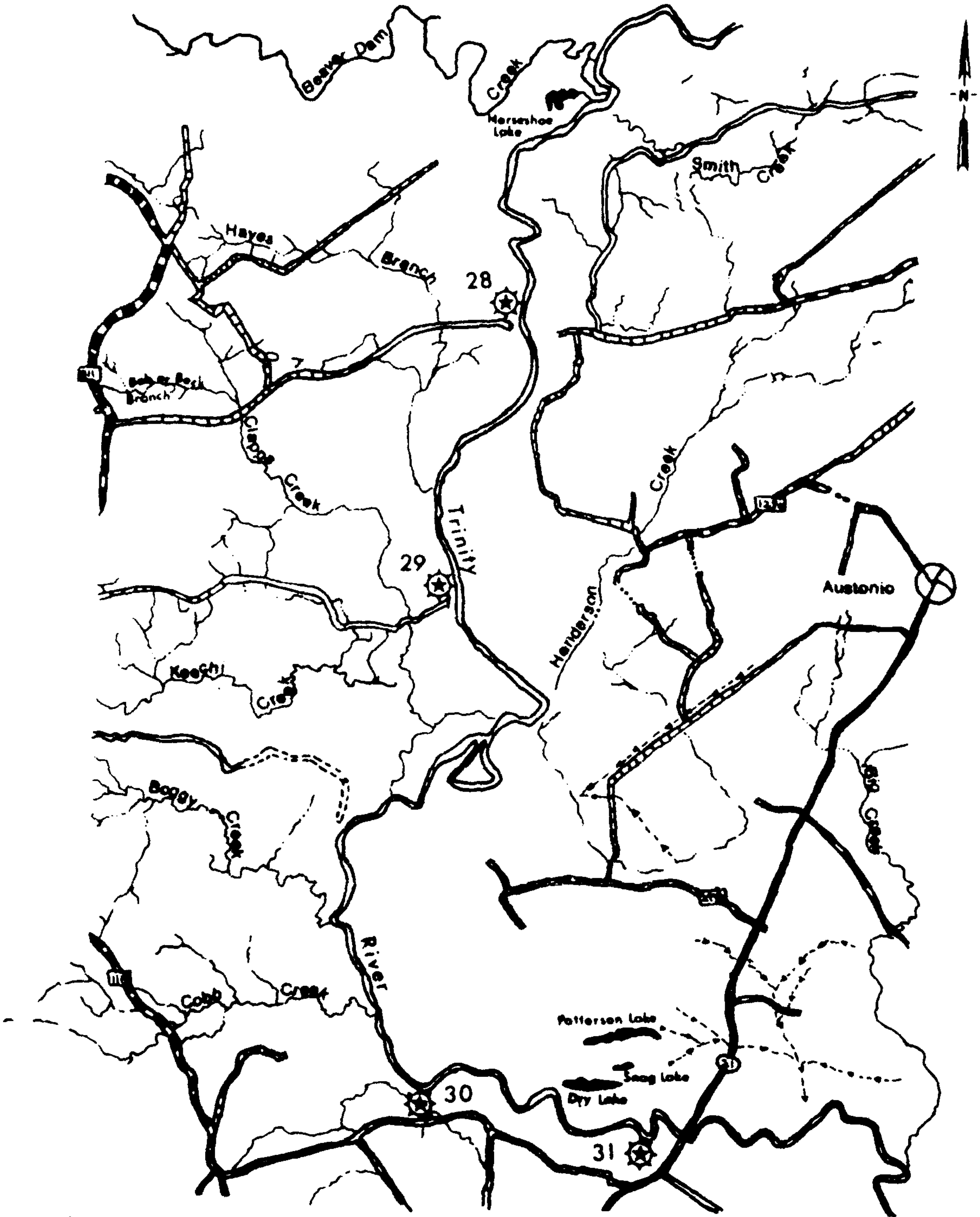

Figure 28. Trinity River Area 8, including Sites 28 through 31.

Table 21. Estimated abundance* of shrub, tree, and woody vine species in Area 8 (See Figure 28).

Species	Sites studied			
	28	29	30	31
Acer negundo		O		LA
Amorpha fruticosa				R
Ampelopsis arborea	F		O-LA	
Berchemia scandens		O		
Betula nigra			LO	
Brunnichia ovata				O
Bumelia lanuginosa		R	A	LA
Callicarpa americana		O	O	O
Campsis radicans	O			O
Carya aquatica	F			
Carya cordiformis			O	VR
Carya illinoinensis	F	A	R	A
Carya texana				O
Celtis laevigata	F	F	R	O
Cephalantus occidentalis			R	
Cercis canadensis		O	O	R
Cocculus carolinus				F
Cornus drummondii		O	VR	VR
Crataegus spathulata		O	O	O

Table 21. Continued

Species	Sites studied 28	29	30	31
Crataegus sp.		O		O-F
Diospyros virginiana	F	O	LA	O
Forestiera acuminata	R	O	VR	O
Fraxinus americana			R	O
Fraxinus pensylvanica	F	O	O	R
Gleditsia aquatica				R
Gleditsia triacanthos	A	F		F
Ilex decidua	F	O		R
Ilex vomitoria			A	
Juniperus virginiana			LA	
Juglans nigra		R		O-LA
Liquidambar styraciflua			A	
Maclura pomifera	O	O		VR
Melia azedarach				VR
Morus rubra		O	F	O
Myrica cerifera			O	
Parthenocissus quinquefolia	F	O		
Pinus taeda			LA	
Planera aquatica			R	R
Platanus occidentalis	R	O	O	F

Table 21. Continued

Species	Sites studied 28	29	30	31
Populus deltoides	F	F	R	R-O
Prosopis glandulosa				LA
Prunus mexicana			R	
Quercus falcata			LA	
Quercus lyrata	O	O		
Quercus macrocarpa	R			LF
Quercus marilandica			O	
Quercus nigra			A	
Quercus phellos		O	F	VR
Quercus shumardii		R	VR	VR
Quercus stellata	LA		O	O
Rhus copallina			LA-D	
Rhus glabra				O
Rhus toxicodendron	A	A	O-LA	A
Rivina humilis				LO
Rubus sp.	F			
Rubus trivialis				F
Sabal minor		R	VR	R
Salix nigra	A	F	LA	O
Sambucus canadensis		LA		
Sapindus saponaria	LA	O		VR
Sassafras albidum			O	

Table 21. Continued

Species	Sites studied 28	 29	 30	 31
Smilax bona-nox			F	F
Smilax rotundifolia			O	F
Symphoricarpus orbiculatus		R		O
Tilia americana		O		R
Tilia floridana				R
Ulmus alata			A	F
Ulmus americana			F	VR
Ulmus crassifolia	A	F-A		A
Ulmus rubra		R		R
Viburnum rufidulum			F	VR
Vitis mustangensis			A	O
Vitis rotundifolia			F	F
Vitis vulpina				A
Zanthoxylum clava-herculis			R	

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

The most unique area along this sector of the river is Falls Canyon situated about four miles north of the Highway 21 bridge (Site 30, Figure 28). The soil, which is a sandy loam, has been greatly eroded, forming a large ravine with measurements up to about 80 feet in depth and over one mile long. The ravine contains Youngs Creek which is generally intermittant. The creek widens and deepens as it approaches the Trinity River and is characterized by several branches. A small creek enters Youngs Creek over a rock ledge resulting in a waterfall of approximately 20 feet. Falls Canyon, therefore, is quite contrasting to the regular scenic expression of the Trinity River Basin.

Dominant woody species in the lower Falls Canyon area included water oak (*Quercus nigra*), gum bumelia (*Bumelia lanuginosa*), mustang grape (*Vitis mustangensis*), sweetgum, yaupon (*Ilex vomitoria*), willow, winged elm (*Ulmus alata*), and locally abundant populations of eastern red cedar (*Juniperus virginiana*), southern red oak, shining sumac (*Rhus copallina*), persimmon (*Diospyros virginiana*), loblolly pine, poison ivy and peppervine (Table 21).

Area 9

Area 9 extends just south of State Highway 21 to the southern limit of Houston County (Figure 29). The large Ferguson and Eastham Prison Farms border the river in this sector. High bluffs usually confine the river, but levees have been built in places to protect vulnerable farmland. The terrain is flat to rolling. Small ponds and creeks are common. Larger tributaries such as Kellisons Creek and Negro Creek enter the river along this section. Agriculture appears to be the dominant land use. One small country home development lies between the Ferguson Prison Farm and Bedias Creek. Most of the bottomland has been cleared for cropland and pasture, usually leaving narrow bands of trees along the river's edge. There are, however, a few relatively large tracts of forest still remaining. These forested areas within 1/2 mile on either side of the river total approximately 2300 acres and have generally been logged, sometimes for the purpose of creating wooded pasture land. There are approximately 4300 acres in this mile-wide strip.

The northern portion of this area is mostly natural pasture land with scattered wooded areas. One potential

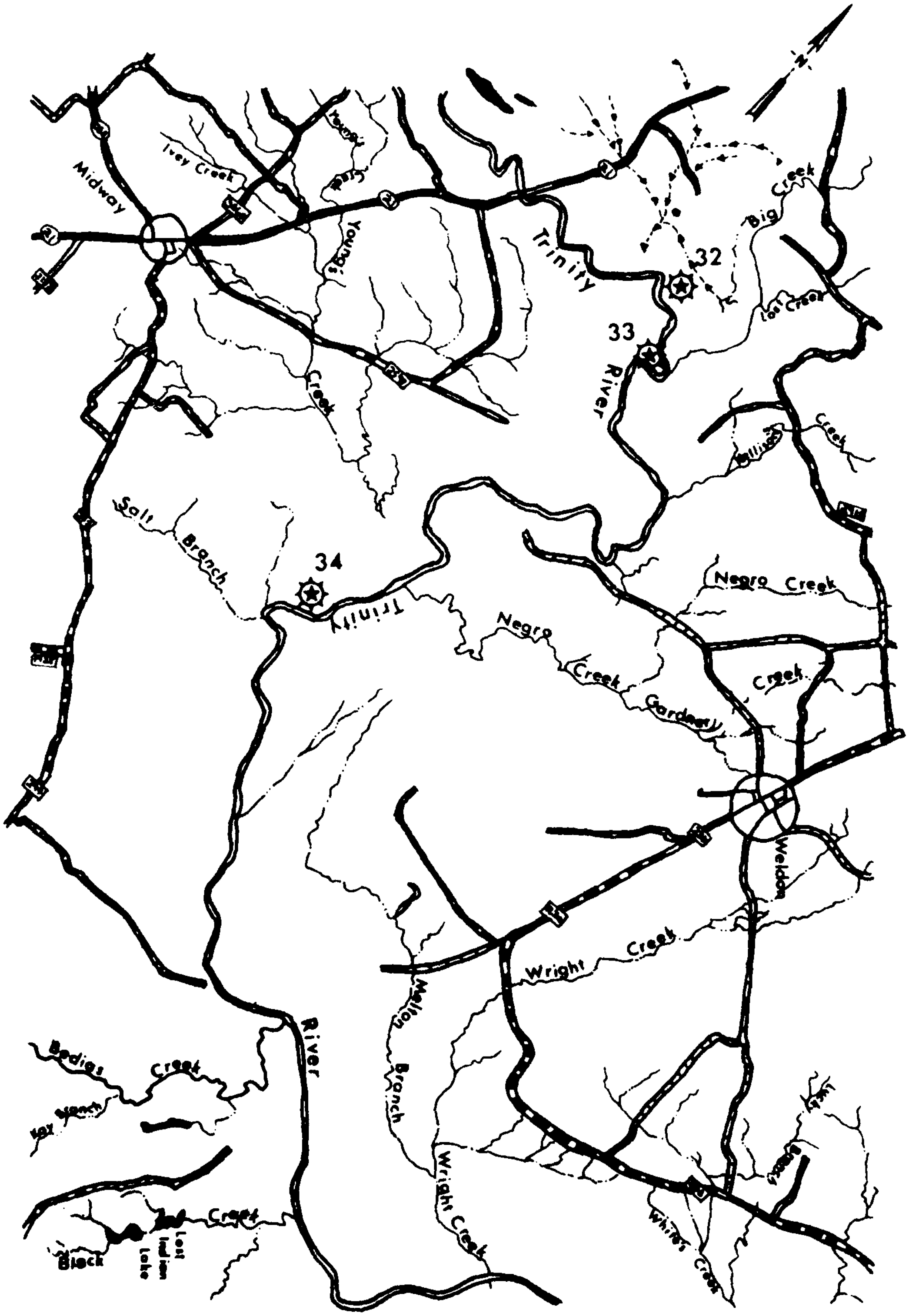

Figure 29. Trinity River Area 9 including Sites 32 through 34.

state champion tree was found on the Clinton Wakefield Ranch (Site 33, Figure 29). This was a water locust (Glenditsia aquatica) measuring 84 inches in circumference, 63 feet in height, and with a crown spread of 47 feet. It had an index* of 159 points, compared to 123 for the present state champion. A cedar elm tree in this same area measured 101 inches in circumference, 80 feet in height, and had a 56 foot crown spread for an unofficial index of 195 points. This is only 9 points below the index for the current state and national champion cedar elm.

Texas sugarberry, honey locust, possum-haw holly (*Ilex decidua*), poison ivy and cedar elm dominated this sector of the river (Table 22). Black willow was locally frequent and swamp privet displayed dense populations in connection with poorly-drained sites.

Area 10

Area 10 extends from just south of the Eastham State Prison Farm in Houston County to the headwaters of Lake Livingston (Figure 30). Tributaries such as White Oak and Black Creeks, Wright Creek, Nelson Creek, White's Creek and Village Creek enter the river in this section and generally witness the effect of backed-up water due to the presence of Lake Livingston. The first large acreages of pine-hardwood forest were noticed in this sector especially in the southern portion. Much of the northern portion has been cleared for pasture and farming including large areas within the Ellis State Prison Farms. Country housing developments are also present in some areas.

In the northern portion of Area 10, White Oak and Black creeks come together forming a large creek which widens into a shallow marsh a short distance above its junction with the Trinity River (Site 35, Figure 30). Many dead trees are present in the marsh. Along one side of the marsh is a high bluff which is dominated by loblolly and shortleaf pine and sweetgum. South of White Oak and Black Creek is a rather extensive forest fronting the river for about 2 miles and extending away from the river for approximately 4 miles.

Across the river opposite the confluence of White Oak and Black Creek and the Trinity River and about 500 yards inland is Horseshoe Lake (Figure 30 , Site 36). This large ox-bow lake is part of an extensive ranch which contains the largest acreage of bush palmetto observed along the river. In addition, the ranch contains

Table 22. Estimated abundance* of shrub, tree, and woody vine species in Area 9 (See Figure 29).

Species	Sites studied 32	33	34
Acer negundo	O	O	
Amorpha fruticosa		R	
Ampelopsis amborea	O	F	F
Bumelia lanuginosa		R	
Campsis radicans	O	O	O
Carya aquatica			O
Carya illinoinensis	O	O	F
Celtis laevigata	A-D	F	F
Cephalanthus occidentalis			O
Cornus drummondii		O	
Crataegus sp.	O	F	O
Diospyros virginiana			O
Forestiera acuminata	A	O	LD
Fraxinus pensylvanica	O	O	F
Gleditsia aquatica		A	
Gleditsia triacanthos	F	A	F
Ilex decidua	F	R	A
Morus rubra		R	VR
Parthenocissus quinquefolia	F		F
Platanus occidentalis	O	O	LA
Populus deltoides		LO	
Quercus lyrata	O		O

Table 22. Continued

Species	Sites studied 32	33	34
Quercus macrocarpa		O	
Quercus phellos	F		R
Quercus prinus	O		O
Quercus shumardii	F		
Quercus stellata		O	
Rhus toxicodendron	A	A	A
Rubus sp.	F	F	F
Sabal minor			D
Salix nigra	LF	LF	O
Saphora affinis		R	
Sapindus saponaria	O		
Smilax bona-nox		F	O
Smilax hispida		F	
Smilax rotundifolia		F	O
Symphoricarpos orbiculatus	F		
Ulmus americana	O	R	
Ulmus crassifolia	A	A	A
Ulmus rubra		O	
Vitis mustangensis		A	

*Abundance is based upon the following scale:

D - Dominant F - Frequent R - Rare
A - Abundant O - Occasional VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

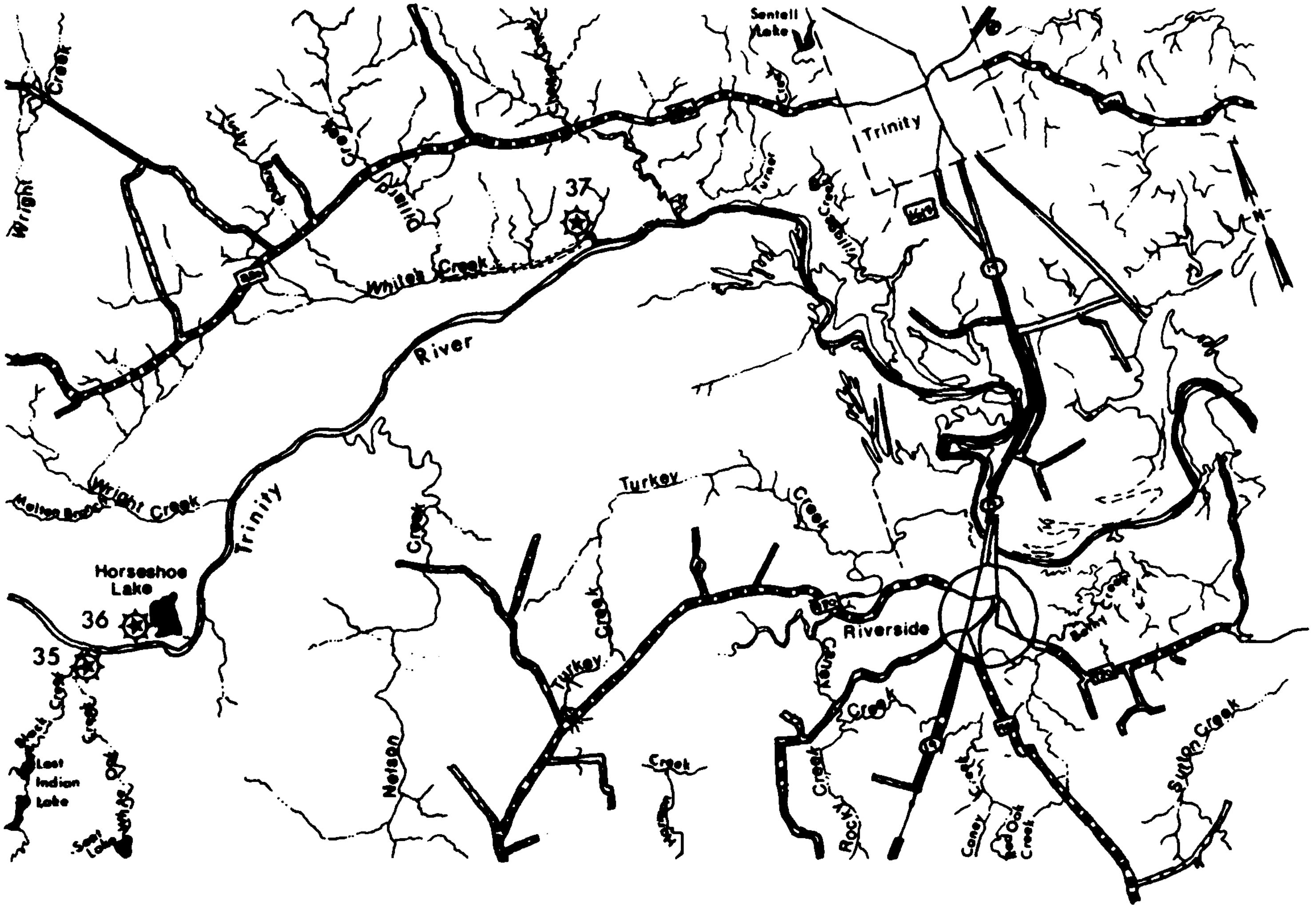

Figure 30. Trinity River Area 10, including Sites 35 through 37.

some 2500 acres of woodland making it one of the more unique sites along the Trinity River.

Site 37 (Figure 30) is centered in a large forested area bordering the river for approximately 4-1/2 miles. The vegetation associated with White's Creek contrasts sharply with upland pine-hardwood forests due to sharp increases in elevation along the east side of the creek. This diversity results in an interesting botanical setting.

The most abundant woody species along this sector of the Trinity River were cedar elm, water hickory (_Carya aquatica_), loblolly pine, possum-haw holly, dwarf palmetto, sweetgum, willow oak and poison ivy (Table 23).

Area 11

Area 11 extends from Lake Livingston dam to just south of the northern Liberty County line (Figure 31). The river is notably less turbid than it was above the reservoir. The land bordering the river is generally flat to gently rolling, but steep bluffs edge much of the river and gently sloping sandy beaches are also common. Small ponds, larger lakes, streams, and small springs lend interest to the land along the river. The numerous ox-bow lakes scattered along the river are mostly small, shallow, covered by duckweed and rather marshy. The larger and deeper lakes have become centers of housing developments.

A great deal of the forest land has been cleared for pasture, with some trees left in the more inaccessible land bordering the river. Some fairly large tracts of forest are also present but these areas too are normally grazed. Country home developments become increasingly numerous.

Although not especially unique, several interesting sites were found along this portion of the river. Two miles south of the Lake Livingston dam-site, near Riviera Estates, what appeared to be a natural lake had emptied into the river (Site 38, Figure 31). The remaining marsh is drained by a small creek meandering through the old lake bed and down a steep bluff to the river. Little woody vegetation is present but the herbaceous vegetation is varied, with many hydrophytic plant species present in and around the old lake bed.

Table 23. Estimated abundance* of shrubs, trees, and woody vine species in Area 10 (See Figure 30).

Species	Sites studied 35	36	37
Acer negundo	R		
Ampelopsis arborea	R	O	F
Berchemia scandens	O		
Bumelia lanuginosa	O	O	F
Callicarpa americana	O		A
Campsis radicans		O	O
Carya aquatica	LD	F	LF
Carya cordiformis.			F
Carya illinoinensis.		O	R
Carya texana			O
Carya tomentosa.			O
Celtis laevigata		F	
Cercis canadensis.			R
Cornus drummondii.			O
Cornus florida			A
Crataegus spathulata		O	O
Crataegus sp.			
Diospyros virginiana	F	F	R
Foresteria acuminata	F		
Fraxinus pensylvanica	F	O	R
Gleditsia aquatica	F		
Gleditsia triacanthos		O	

Table 23. Continued

Species	Sites studied 35	 36	 37
Ilex decidua	A	A	
Ilex vomitoria			A
Liquidambar styraciflua. . . .	A		A
Morus rubra.			O
Pinus echinata	O		O
Pinus taeda.	LD		A
Platanus occidentalis.		LF	
Populus deltoides.		LO	
Quercus alba			VR
Quercus falcata.	O		F
Quercus lyrata	O	F-LA	
Quercus nigra.	O	LF	R
Quercus phellos.	F	LA	R
Quercus shumardii.	R		
Quercus stellata			F
Rhus copallina			O
Rhus glabra.	LA		
Rhus toxicodendron	F		LD
Rubus sp..		F	O
Sabal minor.	O	A-LD	O
Sapindus saponaria		O	
Smilax bona-nox.	F	O	O

Table 23. Continued

Species	Sites studied 35	36	37
Smilax rotundifolia.	F		
Ulmus alata.			F
Ulmus americana.	O		
Ulmus crassifolia.	A	D	R
Viburnum rufidulum	O		R
Vitis mustangensis		O	F
Vitis rotundifolia	O		F

*Abundance is based upon the following scale:

D-- Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

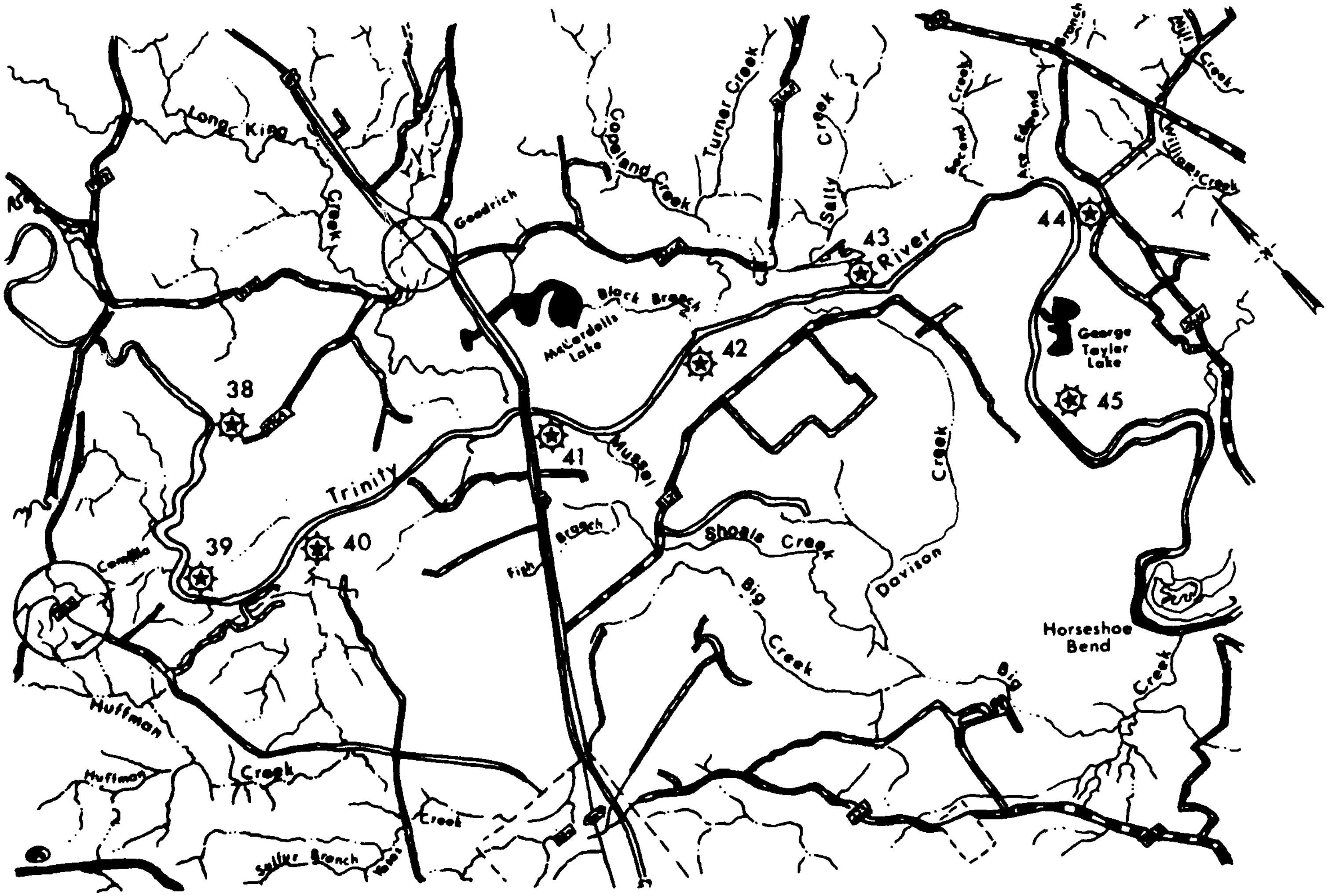

Figure 31. Trinity River Area 11, including Sites 38 through 45.

The Simon Peter Bend Ranch is another interesting area (Site 39, Figure 31). The ranch is mostly flat to gently rolling pasture land, but one fairly large wooded tract of 1300 acres lies near the bend of the river. Small trees and an abundance of various herbaceous species are present in and around the forest. The river is quite scenic from this site, with high bluffs and wide sandbars visible along the shore.

Near Huffman Creek on the west side of the river much of the upland has been cleared. A band of trees, however, has been left on about 30 acres of land (Site 40, Figure 31). A number of small springs arise from a steep bank bordering the south margin of this forest. The vegetation of this site is interesting and somewhat unusual, both from the standpoint of species present and the size of individual trees, particularly sassafras. The area is noteworthy in having a local abundance of Carolina silverbells (*Halesia carolina*). Herbaceous plant species were also diverse and interesting.

The Big Thicket of East Texas as outlined by McLeod (1971) begins east of Highway 59 and borders the river on the east. Sites observed east of Highway 59 in Area 11 did not appear to be of any special significance with the exception of an extensive swamp located about 4 miles west of the river towards the city of Shepherd, Texas. This swamp has been logged in the past but is still a naturally unique area. Bald cypress (*Taxodium distichum*), tupelo (*Nyassa aquatica*) and common buttonbush dominated the wet areas with red mulberry, green ash, cedar elm and water oak inhabiting the drier marginal areas. Another swamp just northeast of the junction of the Trinity River and Highway 59 is a nesting site for cattle egrets and other birds, besides being a botanically unique area.

Dominant species in Area 11 were box elder (*Acer negundo*), pecan, sweetgum, sycamore (*Platanus occidentalis*), poison ivy, black willow (along the river), cedar elm and mustang grape (Table 24).

Area 12

Area 12 included that part of the Trinity River from the Liberty County line to just south of Highway 162 (Figure 32). The terrain is flat to gently rolling with occasional high bluffs. Sandbars and gravel beaches are common along the river, especially south of Highway

Table 24. Estimated abundance* of shrub, tree, and woody vine species in Area 11 (See Figure 31).

Species	Sites studied							
	38	39	40	41	42	43	44	45
Acer negundo		A	A	A	R	F	O	F
Ampelopsis arborea		O	O	F	O	A	O	A
Asimina triloba							LA	LA
Berchemia scandens		O		O				
Bumelia lanuginosa		O	R					
Callicarpa americana			O		F		F	R
Campsis radicans		O				F		
Carpinus caroliniana		O	F					
Carya aquatica		LA		O		R		
Carya cordiformis				O		R	O	R
Carya illinoinensis		F	F	F-A	O	A		A
Carya texana							O	

Table 24. Continued

Species	Sites studied 38	39	40	41	42	43	44	45
Celtis laevigata.		A		F	R		O	F
Cephalanthus occidentalis . . .						R		
Cercis canadensis				F				R
Cornus drummondii		F	O	F	O	F		F
Cornus florida.							R	
Crataegus spathulata.		F		O	F	F		
Crataegus sp.		F				A		
Diospyros virginiana.		O-LA		O	O	A		F
Foresteria acuminata.			O			LA		
Fraxinus pensylvanica	R	O	F	O		O		
Gleditsia triacanthos		F		O	A	F		F
Halesia carolina.			LA					
Ilex decidua.		LA		F	O	F	R	

Table 24. Continued

Species	Sites studied							
	38	39	40	41	42	43	44	45
Ilex opaca			LF					
Ilex vomitoria		O	F	F	O		A	O
Juglans nigra			O	O			O	
Juniperus virginiana				R				
Liquidambar styraciflua		O	A	F	F	F	F	F
Lonicera japonica			O					
Magnolia grandiflora		LO	O					
Morus rubra		VR					O	
Myrica cerifera							A	
Ostrya virginiana			O					
Parthenocissus quinquefolia		F	O	O	F	A		
Pinus echinata			R					
Pinus taeda			O		D		D	

Table 24. Continued

Species	Sites studied 38	39	40	41	42	43	44	45
Planera aquatica.						O		
Platanus occidentalis		O	A	F	O	A	F	F
Populus deltoides				O-LF		F		LD
Prunus serotina				R			O	
Ptelea trifoliata			R					
Quercus alba.			R					
Quercus falcata		O		R		O	F	R
Quercus lyrata.				R		O	F	O
Quercus macrocarpa.						R		
Quercus marilandica							O	
Quercus nigra		O		O				F
Quercus phellos		O						

Table 24. Continued

Species	Sites studied							
	38	39	40	41	42	43	44	45
Quercus prinus		R	R					
Quercus shumardii				R				O
Rhus glabra				O			LA	
Rhus toxicodendron	LF	A	A	F	O	A	A	A
Rubus aboriginum								F
Rubus trivialis	O		O					
Rubus velox		O				A		
Rubus sp.					O			
Sabal minor		R						
Salix nigra	LA	LA	A	LA		LA		LA
Sambucus canadensis		F	O	F		F		A
Sapindus saponaria						O		
Sassafras albidum			LA					R

Table 24. Continued

Species				Sites studied				
	38	39	40	41	42	43	44	45
Smilax bona-nox		F	O		O	F		
Smilax rotundifolia		F		F		F		
Tilia americana								R
Tilia sp.			F	O				
Trachelospermum difforme. . . .				O				
Ulmus alata			R				O	
Ulmus americana		O	R	F		O	O	O
Ulmus crassifolia		A		F	F	F		F
Ulmus rubra			F					
Vaccinium arboreum.			R			R		
Viburnum rufidulum.			R					
Vitis cinerea				O				
Vitis mustangensis.		A	O	F		F	O	A

Table 24. Continued

Species	Sites studied 38	39	40	41	42	43	44	45
Vitis rotundifolia.						F		F
Zanthoxylum clava-herculis. . .			O	F		R		O

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

Figure 32. Trinity River Area 12, including Sites 46 through 56.

105. Planimeter measurements within a half mile on each side of the river indicated some 3500 acres of forests and 1100 acres of cleared land (mainly pastures). It is interesting to note that approximately 1400 acres have been used for the development of country home sites. Lake "estates" are prevalent around ox-bow lakes and along the bluffs of the river.

Overall, this section of the river is interesting because of the extensive acreage of forest land, the diversity of sites, and the varied flora. It is difficult to distinguish unique areas in Area 12 because of continued habitat diversity. Forested areas are not generally very different from other forested areas and ox-bow lakes, ponds and swamps do not show any great variation from one site to another. Ox-bow lakes in the vicinity of the New River Lake development and the surrounding forest land provide a greater than average diversity of species (Site 51, Figure 32). Some fairly large trees were also present. Poorly drained sites supported populations of bald cypress and swamp privet and there was an unusual abundance of chestnut oak (*Quercus prinus*) on the more mesic sites. The Arizona Creek Wildlife Club area which is about 1-1/2 miles north of Hammers Bend Lake has a good habitat and species diversity (Site 53, Figure 32). The area is generally undisturbed except for grazing by cattle. Some large green ash trees measuring up to 115 inches in circumference, 75 feet in height and with a 50-foot crown spread were observed.

The most abundant woody species in Area 12 were box elder, pecan, Texas sugarberry, roughleaf dogwood, persimmon, honey locust, sweetgum, Virginia creeper (*Parthenocissus quinquefolia*), sycamore, eastern cottonwood, poison ivy and black willow (Table 25).

Area 13

The Trinity River bottom from just south of State Highway 162 to south of U. S. Highway 90 in Liberty, Texas was designated as Area 13 (Figure 33). This entire area is generally flat to gently rolling and often poorly drained with small creeks, sloughs, ponds and lakes present. Most of the land along this section of the river is forested, grazed by cattle and logged to varying degrees. A number of country home developments center around oxbow lake and river settings.

Table 25. Estimated abundance* of shrub, tree, and woody vine species in Area 12 (See Figure 32).

Species	Sites studied										
	46	47	48	49	50	51	52	53	54	55	56
Acer negundo	O	R	F	O	O	O	O	F	F		O
Ampelopsis arborea	F	O		F	LA		O	O	O	F	O
Berchemia scandens	O	O				F	O	O	O		O
Bumelia lanuginosa		O									R
Callicarpa americana	O					O		R			
Campsis radicans	O	F	O	R-O		O	O	O	O		O
Carpinus caroliniana										R	VR
Carya aquatica	R.	F		O			F				A
Carya illinoinensis	F	F	A	O	O	F	A	A	F	A	A
Carya tomentosa	O										
Catalpa speciosa				R					R		
Celtis laevigata	F	F	F	O	A	A	F	O	F	D	O

Table 25. Continued

Species	Sites studied 46	47	48	49	50	51	52	53	54	55	56
Cephalanthus occidentalis	R		O		O		R				R
Cercis canadensis	R										
Cornus drummondii	F	R	F	O	A	A	F	O	F	D	O
Crataegus spathulata	O	O		O		R	O		O	O	O
Crataegus sp.	F	O				O					F
Diospyros virginiana	F	F	O	O	F	O	O	O	F	F	O
Forestiera acuminata	O	LF	O		LD				O	LA	LA
Fraxinus pensylvanica	O	LF	O		O	O	O	F		O	O
Gleditsia triacanthos	O	F	O	O	A	O	O	F	O	F	O
Ilex decidua	O	O		F		O		F	F	O	R
Ilex opaca											R
Ilex vomitoria	O								O		VR
Juglans nigra			A								
Juniperus virginiana	O	O									

Table 25. Continued.

Species	46	47	48	49	50	51	52	53	54	55	56
	Sites studied										
Liquidambar styraciflua	O	O	A	O	O	A	O	F	F	F	F
Maclura pomifera				R							
Melia azedarach	R	O	R							R	
Morus alba									VR		
Morus rubra	R	VR	VR			R	R				
Parthenocissus quinquefolia	O F	F	O	O	A	A		F	A	O	O
Pinus taeda		LD									VR
Planera aquatica		LO			LA	LA			R		
Platanus occidentalis	F	LF	F	A	O	F	A	F	O	A	F
Populus deltoides	O	LF	F	R	O	F	A	O	O		A
Quercus alba			VR								VR
Quercus falcata	O		O	R		F	O		O	F	
Quercus lyrata		O	R			O	R	O	O	F	O
Quercus macrocarpa	O									R	

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Table 25. Continued.

Species	Sites studied										
	46	47	48	49	50	51	52	53	54	55	56
Quercus nigra.		O		R		F	O	O		F	F
Quercus phellos.	F						R		O	O	
Quercus prinus	O	LO				A	O	R	A		
Quercus shumardii.	R	R	A					O	O		R
Rhus toxicodendron	A	F	O	F	A	A	A	A	A	A	F
Rubus aboriginum		O	F			A	F	A	A	A	
Rubus saepescandens.				F							
Rubus sp..	F			F	LD						A
Sabal minor.								R	O	R	VR
Salix nigra.	A	LF	LA	A	O	LA	A		F	O	F
Sambucus canadensis.	A		O		LA	LA	F	F	O	F	O
Sapindus saponaria										O	
Sapium sebiferum							R				
Smilax bona-nox.	O	O	O			F		O	F		

Table 25. Continued.

Species	Sites studied										
	46	47	48	49	50	51	52	53	54	55	56
Smilax hispida				O							
Smilax rotundifolia	O	O				F		O	F	O	O
Symphoricorpus orbiculatus										R	
Taxodium distichum	F	LA			LA	LA	F		R	LA	VR
Tilia americana		O	O			R					
Tilia florida				R							
Trachelospermum difforme				O							
Ulmus alata	R										VR
Ulmus americana		A	A			O	R	F	O	O	
Ulmus crassifolia	O	O					O	R	O	A	O
Ulmus rubra	O	F	O			O	O	R			O
Vaccinium arboreum						R		LA			
Vitis cinerea											O
Vitis mustangensis	O	R	F	F	LA		O		A		O

Table 25. Continued.

Species	Sites studied										
	46	47	48	49	50	51	52	53	54	55	56
<u>Vitis</u> <u>rotundifolia</u>		R		O		F			A		O
<u>Vitis</u> <u>vulpina</u>.				O							
<u>Zanthoxylum</u> <u>clava-herculis</u> . .		F-LA	O	R		R	R	O	O		O

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

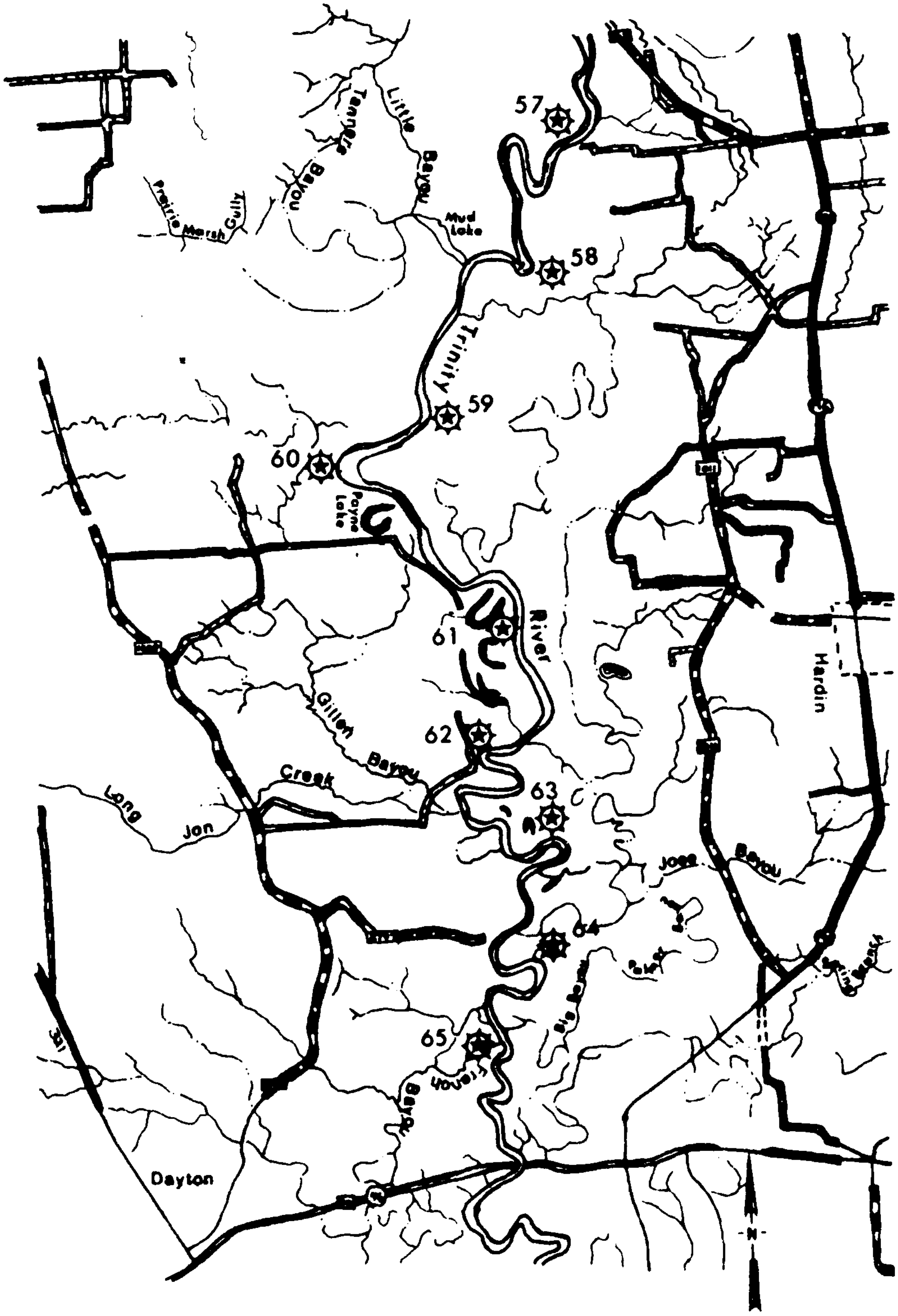

Figure 33. Trinity River Area 13, including Sites 57 through 65.

That portion of the Trinity River from Highway 162 south to Liberty, Texas is the most extensive forested area encountered in this study. Measurements within 1/2 mile on either side of the river indicated the presence of over 8000 acres of forests and 800 acres of cleared land. Housing developments incorporated approximately 900 acres.

The Tanner Bayou area, south and west of the Highway 162 bridge, is one of the more unique areas along the river (Site 57, Figure 33). Part of an extensive wooded area with poor access, this tract gives the impression of being isolated and seldom visited, despite its obvious use for grazing. A number of bayous and intermittent streams are present. Mud Lake, a large ox-bow lake, is connected to the river by a deep stream 8 to 15 feet wide which can be navigated in a small boat for several hundred yards. Smaller ponds and sloughs are also present. A short distance southwest of the junction of State Highway 162 and the river is a bird rookery, adding another feature to an already interesting habitat. Prevalent woody plant species found included large specimens of eastern cottonwood, sweetgum, sycamore, water hickory, pecan and chestnut oak (Table 26).

The Daniel Ranch, a vast extensive forest comprising much of the land on the east side of the river within Area 13, is significant due to its size and habitat variability (Sites 63 and 64, Figure 33). The large forest is generally characterized by a fairly open canopy, but in some areas the overstory is dense. Abundance of understory plants is also variable with some areas almost impenetrable. Bald cypress, swamp privet, cedar elm and buttonbush dominated margins of ponds and poorly drained sites, while duckweed and water-hyacinths were especially abundant in ponds alongside a levee which parallels the river. Better drained sites support pecan, honey locust, Texas sugarberry, green ash and other common bottomland hardwood species.

On the west side of the river just north of Liberty, Texas one encounters the Jamison Ranch (Site 65, Figure 33). The forested areas and habitat types are much the same as those of the Tanner Bayou and Daniel Ranch areas. A good diversity of woody species is present with box elder, pecan, roughleaf dogwood, hawthorn (Crataegus spp.), persimmon, honey locust, sweetgum, poison ivy, peppervine and mustang grape being the most abundant (Table 26). One large pecan tree measured 12.6 feet in circumference.

Table 26. Estimated abundance* of shrubs, trees, and woody vine species in Area 13 (see Figure 33).

Species	Sites studied								
	57	58	59	60	61	62	63	64	65
Acer negundo	R				R	F		R	A
Ampelopsis arborea	A		F	F	LA	F	F	F	A
Berchemia scandens	O	O	R	O			O		O
Bumelia lanuginosa	O	F						R	O
Callicarpa americana			LA						
Campsis radicans	O	O	O	F		F	A	F	
Carya aquatica	A			F	F	A	F	A	F
Carya cordiformis							R		
Carya illinoinensis	A	A	A	A	A	F	A	O	A
Carya ovata							VR		
Celtis laevigata	F	A	A	F	A	O	A	F	F
Cephalanthus occidentalis		LA					A	LA	
Citrus trifoliata				LA					

Table 26. Continued

Species	Sites studied 57	58	59	60	61	62	63	64	65
Cornus drummondii	A	O	O	A	O	R	O		A
Cornus florida	R								
Crataegus spathulata	F	F	O	O	O		F	A	F
Crataegus sp.	F		F	O			O	F	A
Diospyros virginiana	F	F		F	O	O	A	F	A
Forestiera acuminata	LD		O		F			O	R
Fraxinus americana		R				R			
Fraxinus pensylvanica	R	O	O	F	R	F	A	A	F
Gleditsia triacanthos	O	A	F	F	O	O	A	O	A
Ilex decidua	O	F	O	F	R		O	A	
Ilex opaca		VR	VR						VR
Ilex vomitoria	VR	F					O		R
Juglans nigra			LF						
Liquidambar Styraciflua	A	O	A	F	F	O	O		A

Table 26 Continued

Species	Sites studied 57	58	59	60	61	62	63	64	65
Melia azedarach			VR		R				
Morus rubra	O			VR				VR	
Parthenocissus quinquefolia . .	F	F	A	F	O	O		O	F
Pinus taeda									VR
Platanus occidentalis	A	LF	LF	LF	F	LA	A	LF	LA
Populus deltoides	F		O		R	LA	A	LF	LF
Quercus falcata	O	O	LF	R					R
Quercus lyrata.		F	O	F	R	F	F	A	O
Quercus macrocarpa.							F	R	
Quercus nigra	VR		O	F	O		O		F
Quercus phellos		A	O				O	O	
Quercus prinus.	O	VR	A						VR
Quercus shumardii		O	LA		O	O	O	F	R
Rhus toxicodendron.	A	A	A	A	A	A	A	A	A

Table 26. Continued

Species	Sites studied								
	57	58	59	60	61	62	63	64	65
Rubus aboriginum		A	A	A			F	LF	A
Rubus apogaeus						LA			
Rubus sp.	A								
Sabal minor		O						VR	R
Salix nigra		LF	LA			F	A	LF	LA
Sambucus canadensis	O			O	LA	O			LA
Sapindus saponaria		O							
Sapium sebiferum			VR			R	O	VR	F
Smilax bona-nox				O	O		O	O	R
Smilax hispida	O								
Smilax rotundifolia	O							F	O
Symphoricarpus orbiculatus					R				
Taxodium distichum	O	R	LA	LF	LA	R	LA	R	O
Tilia americana		O							
Ulmus alata			O						

Table 26. Continued

Species	Sites studied 57	58	59	60	61	62	63	64	65
Ulmus americana				F			F		O
Ulmus crassifolia	O	A	O			LA	A	A	O
Ulmus rubra	O	O	O	O	R		O	O	O
Vitis mustangensis.	A	F	F	O			F		A
Vitis rotundifolia.		O	O	O				R	
Zanthoxylum clava-herculis. . .			O		R				

*Abundance is based upon the following scale:

D - Dominant
A - Abundant
F - Frequent
O - Occasional
R - Rare
VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

Area 14

Area 14 extends from Liberty, Texas to Interstate Highway 10 in Chambers County (Figure 34). The entire area could be described as low, flat, poorly drained, and pocked with many small ponds, ox-bow lakes, marshes, swamps, bayous. The most frequently occurring woody species were water hickory, persimmon, swamp privet, honey locust, sycamore, poison ivy, black willow and bald cypress (Table 27).

The area just south of Liberty, Texas has generally been developed. Clearings, roads and sloughs with bordering forests are fairly common. The more scenic and undist bed forests are located further south. Although country home developments are present, some forested areas are relatively undisturbed. The area around the Timberlake Estates (Site 67, Figure 34) was interesting from the standpoint of diversity of plant life. Within a short distance from the water, the vegetation changed from streamside species to upland loblolly pine and hardwood forests. Predominant woody species were sweetgum, sycamore, Texas sugarberry, water oak, water hickory, persimmon, loblolly pine, box elder, black willow, poison ivy, roughleaf dogwood, and American elder (Sambucus canadensis) (Table 27).

Localized and Endemic Woody Species

One hundred forty-eight species of woody plants were observed in the Trinity River study area (Table 28). With the exception of ten species, all were widely distributed within the United States. Amorpha (Amorpha paniculata) and mustang grape (Vitis mustangensis) are restricted to eastern Texas, Louisiana, Arkansas, and Oklahoma. Eve's necklace (Sophora affinis) is found only in Arkansas, Oklahoma, and Louisiana in addition to its presence in north and central Texas and the Edwards Plateau of Texas. Texas nightshade (Solanum triquetrum) occurs only in central, south, and west Texas and in adjacent portions of Mexico. The blackberry Rubus saepescandens is found in sandy open areas in East Texas and also in southern Louisiana.

Five species observed were endemic to this region. Brazos hawthorn (Crataegus brazoria) occurs only in eastern Texas and the Blackland Prairies. The hawthorn Crataegus glabriuscula is endemic to north-central and south Texas. Texas red oak (Quercus texana) is restricted to the rocky limestone slopes of central Texas. Two species of blackberry, Rubus aborigium and Rubus apogaeus, are found only in eastern Texas (Correll and Johnston, 1970).

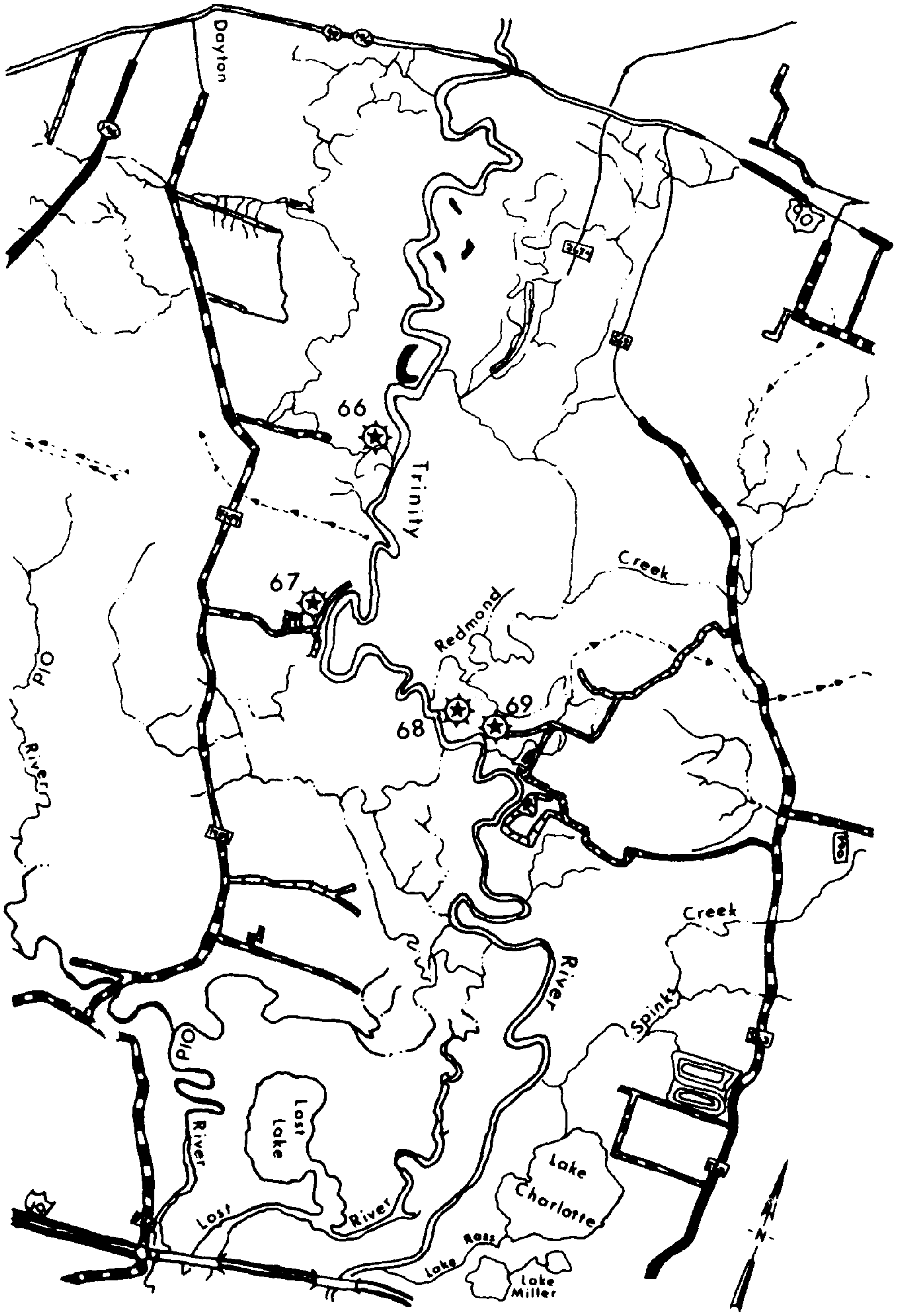

Figure 34. Trinity River Area 14, including Sites 66 through 69.

Table 27. Estimated abundance* of shrub, tree, and woody vine species in Area 14 (See Figure 34).

Species	Sites studied 66	 67	 68	 69
Acer negundo		F		
Acer rubrum		O		
Ampelopsis arborea	O	O	A	O
Berchemia scandens			R	
Callicarpa americana		O		
Campsis radicans	O		R	
Carpinus caroliniana		O		
Carya aquatica	A	F	A	F
Carya illinoinensis		O	A	O
Carya ovata				R
Celtis laevigata	O	F	A	O
Cephalanthus occidentalis				A
Cornus drummondii	O	F		R
Crataegus spathulata	F		R	R
Crataegus spp.			R	
Diospyros virginiana	F	F	LA	O
Forestiera acuminata	F	O	F	A
Fraxinus americana		O		
Fraxinus pensylvanica			F	O

Table 27. Continued

Species	Sites studied			
	66	67	68	69
Gleditsia aquatica				O
Gleditsia triacanthos	A		F	R
Ilex decidua	F		O	
Ilex vomitoria		O		
Juglans nigra		O		
Liquidambar styraciflua	R	F	R	F
Magnolia grandiflora		O		
Melia azedarach		O		
Morus rubra		O		
Myrica cerifera		R		
Parthenocissus quinquefolia		O		
Pinus taeda		F		
Planera aquatica	O			
Platanus occidentalis	F	F	LD	A
Populus deltoides		O		
Quercus falcata	R	O		
Quercus lyrata	R	O	O	
Quercus macrocarpa			O	
Quercus nigra		F		LA
Quercus phellos				O
Quercus prinus		R		
Quercus shumardii		O	O	R

Table 27. Continued

Species	Sites studied			
	66	67	68	69
Rhus copallina		O		
Rhus toxicodendron	F	A	A	A
Rosa spp.				A
Rubus spp.	F			O
Sabal minor		R		
Salix nigra	A	A		A
Sambucus canadensis		F		LA
Sapindus saponaria		O		
Sapium sebiferum		O	A	A
Smilax bona-nox	O		O	
Smilax hispida			O	
Taxodium distichum	F		F	A
Tilia americana		R		
Ulmus americana	R			
Ulmus crassifolia	A		O	
Ulmus rubra	R	O		
Vitis rotundifolia		O		
Zanthoxylum clava-herculis				LA

*Abundance is based upon the following scale:

D - Dominant F - Frequent R - Rare
A - Abundant O - Occasional VR - Very Rare

The letter "L" in front of any of the letters above indicates local abundance.

Table 28. Preliminary checklist of shrub, tree, and woody vine species within the Trinity River Basin

	Scientific Name	Common Name
1	*Acer negundo* L.	Box elder
2	*Acer rubrum* L.	Red maple
3	*Acer saccharum* Marsh.	Sugar maple
4	*Alnus serrulata* (Ait.)Willd.	Smooth alder
5	*Amorpha fruticosa* L.	Bastard indigo
6	*Amorpha paniculata* T.& G.	Amorpha
7	Ampelopsis arborea (L.) Koehne.	Pepper vine
8	*Ampelopsis cordata* Michx.	Heartleaf ampelopsis
9	*Aristolochia tomentosa* Sims.	Wooly dutchman's pipe
10	*Ascyrum hypericoides* L.	St. Andrew's Cross
11	*Ascyrum stans* Michx.	St. Peter's-wort
12	*Asimina triloba* (L.) Dun.	Pawpaw
13	*Baccharis halimifolia* L.	Sea-myrtle
14	*Baccharis neglecta* Britt.	Roosevelt weed
15	*Berchemia scandens* (Hill.) K. Koch	Rattan vine
16	*Betula nigra* L.	River birch
17	*Brunnichia ovata* (Walt.) Shinners.	Eardrop vine
18	*Bumelia lanuginosa* (Michx.) Pers.	Gum bumelia
19	*Callicarpa americana* L	American beautyberry
20	*Campsis radicans* (L.) Seem.	Trumpet honeysuckle
21	*Carpinus caroliniana* L.	Blue beech
22	*Carya aquatica*(Michx.F.)Nutt.	Water hickory

Table 28. Continued

	Scientific Name	Common Name
23	*Carya cordiformis* (Wang.) K. Koch.	Bitternut hickory
24	*Carya illinoinensis* (Wang.) K. Koch.	Pecan
25	*Carya ovata* (Mill.) K. Koch	Shagbark hickory
26	*Carya texana* Buckl.	Black hickory
27	*Carya tomentosa* Nutt.	Mockernut hickory
28	*Catalpa speciosa* Worder.	Catalpa
29	*Celtis laevigata* Willd.	Texas sugarberry
30	*Celtis reticulata* Torr.	Netleaf hackberry
31	*Cephalanthus occidentalis* L.	Common buttonbush
32	*Cercis canadensis* L.	Redbud
33	*Cissus incisa* (Nutt.) Des Moul.	Cow-itch
34	*Citrus trifoliata* L.	Bitter orange
35	*Cocculus carolinus* (L.) DC.	Red-berried moonseed
36	*Cornus drummondii* C. A. Mey.	Roughleaf dogwood
37	*Cornus florida* L.	Flowering dogwood
38	*Crataegus brazoria* Sarg.	Brazos hawthorne
39	*Crataegus crus-galli* L.	Cockspur hawthorn
40	*Crataegus glabriuscula* Sarg.	Hawthorn
41	*Crataegus marshallii* Eggl.	Parsley hawthorn
42	*Crataegus mollis* Scheele.	Downy hawthorn
43	*Crataegus spathulata* Michx.	Pasture haw

Table 28. Continued

	Scientific Name	Common Name
44	Crataegus viridis L.	Green hawthorn
45	Cucurbita foetidissima H.B.K.	Buffalo-gourd
46	Diospyros virginiana L.	Persimmon
47	Euonymus atropurpureus Jacq.	Burning bush
48	Forestiera acuminata (Michx.) Poir	Swamp privet
49	Forestiera ligustrina (Michx.) Poir	Forestiera
50	Fraxinus americana L.	White ash
51	Fraxinus pensylvanica Marsh.	Green ash
52	Gleditsia aquatica Marsh.	Water locust
53	Gleditsia triacanthos L.	Honey locust
54	Halesia carolina L.	O'possum-wood
55	Ilex decidua Walt.	Deciduous holly
56	Ilex opaca Ait.	American holly
57	Ilex vomitoria Ait.	Yaupon
58	Juglans nigra L.	Black walnut
59	Juniperus virginiana L.	Eastern red cedar
60	Ligustrum quihoui Carr.	Wax-leaf ligustrum
	Ligustrum spp.	Privet
61	Liquidambar styraciflua L	Sweetgum
62	Lonicera japonica Thunb.	Japanese honeysuckle
63	Maclura pomifera (Raf.) Schneid.	Osage orange

Table 28. Continued

	Scientific Name	Common Name
64	*Magnolia grandiflora* L	Southern magnolia
65	*Matelea gonocarpa* (Walt.) Shinners.	Milkvine
66	*Melia azedarach* L.	Chinaberry
67	*Melothria pendula* L.	Drooping melonette
68	*Morus alba* L.	White mulberry
69	*Morus rubra* L.	Red mulberry
70	*Myrica cerifera* L.	Wax myrtle
71	*Nyssa sylvatica* Marsh.	Black gum
72	*Nyssa aquatica* L.	Tupelo
73	*Ostrya virginiana* (Mill.) K. Koch.	American hop-hornbeam
74	*Parkinsonia aculeata* L.	Retama
75	*Parthenocissus quinquefolia* (L.) Planch.	Virginia creeper
76	*Passiflora incarnata* L.	Maypop passionflower
77	*Passiflora lutea* L.	Yellow passionflower
78	*Pinus echinata* Mill.	Shortleaf pine
79	*Pinus taeda* L.	Loblolly pine
80	*Planera aquatica* (Walt.) J. F. Gmel.	Water elm
81	*Platanus occidentalis* L.	Sycamore
82	*Populus deltoides* Marsh.	Eastern cottonwood
83	*Prosopis glandulosa* Torr.	Honey mesquite
84	*Prunus angustifolia* Marsh.	Chickasaw plum

Table 28. Continued

	Scientific Name	Common Name
85	*Prunus mexicana* Wats.	Mexican plum
86	*Prunus persica* (L.) Batsch.	Peach
87	*Prunus serotina* Ehrh.	Black cherry
88	*Ptelea trifoliata* L.	Skunk-bush
89	*Quercus alba* Michx.	White oak
90	*Quercus falcata* Michx.	Southern red oak
91	*Quercus incana* Vartr.	Sandjack oak
92	*Quercus laurifolia* Michx.	Laurel oak
93	*Quercus lyrata* Walt.	Overcup oak
94	*Quercus macrocarpa* Michx.	Bur oak
95	*Quercus marilandica* Muench.	Blackjack oak
96	*Quercus nigra* L.	Water oak
97	*Quercus phellos* L.	Willow oak
98	*Quercus prinus* L.	Chestnut oak
99	*Quercus shumardii* Buckl.	Shumard red oak
100	*Quercus similis* Ashe.	Bottomland post oak
101	*Quercus stellata* Wang.	Post oak
102	*Quercus texana* Buckl.	Texas red oak
103	*Rivina humilis* L.	Pigeon-berry
104	*Rhamnus caroliniana* Walt.	Indian cherry
105	*Rhus aromatica* Ait.	Fragrant sumac
106	*Rhus copallina* L.	Shining sumac
107	*Rhus glabra* L.	Smooth sumac
108	*Rhus toxicodendron* L.	Poison ivy

Table 28. Continued

	Scientific Name	Common Name
109	*Robinia pseudo-acacia* L.	Black locust
110	*Rosa setigera* Michx.	Prairie rose
	Rosa spp.	Rose
111	*Rubus aboriginum* Rydb.	Dewberry-blackberry
112	*Rubus apogaeus* Bailey.	Dewberry-blackberry
113	*Rubus saepescandens* Bailey	Dewberry-blackberry
114	*Rubus trivialis* Michx.	Southern dewberry
	Rubus spp.	Dewberry-blackberry
115	*Sabal minor* (Jacq.) Pers.	Bush palmetto
116	*Salix nigra* Marsh.	Black willow
117	*Sambucus canadensis* L.	American elder
118	*Sapindus saponaria* L.	Soap berry
119	*Sapium sebiferum* (L.) Roxb.	Chinese tallow tree
120	*Sassafras albidum* (Nutt.) Nees.	Sassafras
121	*Smilax bona-nox* L.	Cat-brier
122	*Smilax hispida* Muhl.	Bristly green-brier
123	*Smilax rotundifolia* L.	Common green-brier
124	*Solanum triquetrum* Cav.	Texas nightshade
125	*Sophora affinis* T. & G.	Eve's necklace
126	*Symphoricarpos orbiculatus* Moench.	Coral-berry
127	*Tamarix gallica* L.	Saltcedar
128	*Taxodium distichum* (L.) Rich.	Bald cypress
129	*Tilia americana* L.	American basswood

Table 28. Continued

	Scientific Name	Common Name
130	*Tilia caroliniana* Mill.	Carolina basswood
131	*Tilia floridana* Small.	Florida basswood
132	*Trachelospermum difforme* (Walt.) Gray.	American starfasmine
133	*Ulmus alata* Michx.	Winged elm
134	*Ulmus americana* L.	American elm
135	*Ulmus crassifolia* Nutt.	Cedar elm
136	*Ulmus rubra* Muhl.	Slippery elm
137	*Vaccinium arboreum* Marsh.	Farkleberry
138	*Viburnum nudum* L.	Possum-haw
139	*Viburnum rufidulum* Raf.	Southern blackhaw
140	*Vitex agnus-castus* L.	Chaste lamb-tree
141	*Vitis aestivalis* Michx.	Summer grape
142	*Vitis cinerea* Engelm.	Sweet grape
143	*Vitis mustangensis* Buckl.	Mustang grape
144	*Vitis palmata* Vahl.	Red grape
145	*Vitis riparia* Michx.	Frost grape
146	*Vitis rotundifolia* Michx.	Muscadine grape
147	*Vitis vulpina* L.	Winter grape
	Vitis spp.	Grape
148	*Zanthoxylum clava-herculis*	Hercules-club

Famous and Champion Big Trees

According to data assembled by Mahler (Sciscenti, 1971), there are ten famous trees of historical value within the watershed of the Trinity River. In addition, twenty-four Champion Big Trees occur in the counties bordering the river. Three of the Champion Big Trees, one of them also listed among the famous trees, are situated within one mile of the river.

In addition, two new Champion Big Trees have been located, and later officially confirmed during the impact study of the proposed Tennessee Colony Reservoir (Stephen F. Austin State University, 1972). These added champions were trees of honey locust (*Gleditsia tricanthos*) and green ash (*Fraxinus pennsylvanica*). Although not yet confirmed, a water locust tree (*Gleditsia aquatica*) found in Madison County is much larger than the present state champion for this species.

SUMMARY

To characterize the vegetation of the Trinity River Basin is a monumental task. It is important initially to work up checklists of plant species inhabiting the basin and to locate areas that are unique or of special interest botanically. This study focused upon these aspects. Results of this study indicate that the following sites should be studied in-depth, including the acquisition of frequency, density, dominance and species diversity data. Other data may be obtained as necessary.

1. The Post and Paddock Riding Club area (Site 8, Figure 21) between Fort Worth and Dallas.

2. The Fin and Feather Hunting and Fishing Club area (Site 14, Figure 23) southeast of Dallas.

3. Within the proposed Tennessee Colony Reservoir area:
   a. The bird rookery at Sand Lake is also interesting from a vegetational standpoint.
   b. Forested area on Stephens Lake Ranch between Highways 31 and 287.
   c. Forested area with bush palmetto on Wildcat Ranch south of Highway 287.
   d. Extensive hardwood forest north of Highway 84-79.
   e. Rush and Indian Creeks.

4. Falls Canyon area just north of the Highway 21 bridge (Site 30, Figure 28).
5. Wakefield Ranch (Site 33, Figure 29) south of Highway 21 bridge, mainly for herbaceous species.
6. Forested areas in connection with Sites 35, 36, and 37 (Figure 30) between Highways 21 and 19.
7. Forested area (Site 40, Figure 31) positioned on a slope between the Lake Livingston dam and Highway 59.
8. The bird rookery northeast of the junction of the Trinity River and Highway 59 is also of interest vegetationally.
9. Coley's Swamp east of Shepherd, Texas, on the west side of the river.
10. Forested area (Site 51, Figure 32) between Highways 105 and 162.
11. Representative sites within the Tanner Bayou (Site 57, Figure 33), Daniel Ranch (Sites 63 and 64, Figure 33), and Jamison Ranch (Site 65, Figure 33), areas located between Highways 162 and 90.

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CHAPTER V

AN INVENTORY AND CHECKLIST OF THE FISHES OF THE LOWER TRINITY RIVER DRAINAGE SYSTEM

by

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INTRODUCTION

The fish fauna of the eastern half of Texas in general, and the Trinity River Drainage System in particular, has been poorly and inadequately studied in the past. This has been due to the relatively great distance of the river systems of East Texas from major ichthyological research centers. No complete inventory of the fish species present in the Trinity River system has been made to date. Most "inventories" have been piecemeal or cursory attempts with little or no attention given to ecological factors governing the distribution of fishes within the system. This study does little to clarify the ecological problems, but does document the occurrence of most of the fish species now present in the lower Trinity River drainage.

The area sampled in this study is defined as that portion of the Trinity River and certain tributaries lying partially or wholly within the Texas counties of: Polk, San Jacinto, Liberty, and Chambers.

In an inventory of the fishes of the Trinity River, Lamb (1957) listed only 57 fish species from the entire Trinity River watershed. This is (and probably was at the time) inaccurate, as will be discussed later in this report. Studies by Boyd (1968) and Altaras (1972) have documented the occurrence of 42 and 32 fish species in Bedias Creek and Harmon Creek, respectively. Both streams are tributaries of the lower Trinity River. Eleven species were reported by Boyd which Lamb did not include and five additional species were reported by Altaras which were not noted by Lamb.

Hubbs (1961) Checklist of Texas Fresh Water Fishes is a useful guide to the fishes of Texas, but lists fishes by geographical regions only and does not specifically deal with fishes of the Trinity River system.

Extensive collecting from May-August, 1972 was conducted in order to determine the fish species extant in the lower Trinity River. Additional data regarding fish species of the Trinity River have been taken from Lamb (1957), Hubbs (1961), McCune (1971), and Altaras (1972) and are included herein.

Quantification and standardization of techniques in fisheries surveys are often difficult, if not impossible, goals. Many variables are usually encountered in field work of this nature which preclude precise analysis and concrete statements regarding the fish populations present. All available sampling tools and techniques, however, were used during this survey to effect as complete an inventory as possible within the time period allocated. Small and/or terete fish species may not have been captured because of mesh sizes of the minnow seines used (1/4" and 3/8" mesh sizes). This is not regarded as a serious handicap, however, since practically all fish species populations possess some individuals which are large enough to be taken by the mesh sizes indicated above.

MATERIALS AND METHODS

Field studies began on this phase of the Trinity River Project on May 26, 1972, and were terminated August 5, 1972. Nine sampling stations were established on the Trinity River proper and numerous collections were made on tributaries, swamps, and oxbow lakes on the floodplain of the lower Trinity River.

Fishes were collected with: common sense minnow seines (1/2" and 3/8" mesh sizes), dip nets, gill nets, drag seines, rotenone, hand, rod-and-reel, and trotline. Fishes were preserved immediately in the field in 10% formalin and later, in the lab, were sorted, identified, cataloged, and placed in fresh 10% formalin.

A 16-foot flat bottom Jon boat and 20 h.p. Johnson outboard motor were used for reconnaissance and collecting trips on the Trinity River proper. A 14-foot Jon boat and 7.5 h.p. Sears outboard motor were used on oxbow lakes, swamps and small tributaries.

Air and water temperatures were obtained during each collection, as well as data regarding aquatic vegetation, bottom type, water depth, flow velocity, method of capture, and turbidity. These data were recorded in the field on prepared data sheets.

U.S. Geological Survey maps and Texas State Highway Department maps were used to determine station locations both on the Trinity River and its tributaries. Aerial reconnaissance via helicopter was used to locate small, poorly-defined tributaries and access routes to these tributaries.

Collecting sites are shown in Figure 35 . Collecting stations on the river mainstream are designated by numbers, whereas stations on tributaries are indicated by black dots. Stations were selected primarily on the basis of accessibility and diversity of habitats present.

Taxonomic keys used for identifying fishes collected in this survey included: Moore (1968), Hubbs (1970), Eddy (1957), Smith-Vaniz (1968), and Parker et al. (1971).

RESULTS

In this three-month study 9565 fishes were collected which represented 18 families, 38 genera, and 68 species. A previous five-year (1953-1957) study by Lamb (1957) documented the occurrence of only 57 species of fish in the entire Trinity River system, with at least one of these species listed being in doubt (the shortnose gar, Lepisostues platostomus) since the species is unknown to commercial fishermen of the lower Trinity River in the area in which it was supposedly collected. We did not collect the species during this survey. It appears likely that an undescribed gar species of the lower Trinity River was collected by Lamb and associates, superficially examined and then listed as the "shortnose gar." It also appears that many of the species listed in Lamb's (1957) report were not actually captured by him or the personnel working under his supervision since no quantative data were included for at least five species reported, namely the: suckermouth minnow, sand shiner, plains minnow, stoneroller, and logperch. These species may have been listed on the basis of hearsay or publications not cited in his report.

At least one species, the paddlefish, Polyodon spathula, has disappeared from the Trinity River within the past 12-20 years. No paddlefish were collected by Lamb and none were taken during this survey. At present the paddlefish probably occurs in Texas only in the Sabine and Red River drainage systems (pers. comm., Lloyd Brannen, Commercial Fisherman, Liberty, Texas). McCune (1971) listed the paddlefish as occurring in the Trinity River but this is probably in error.

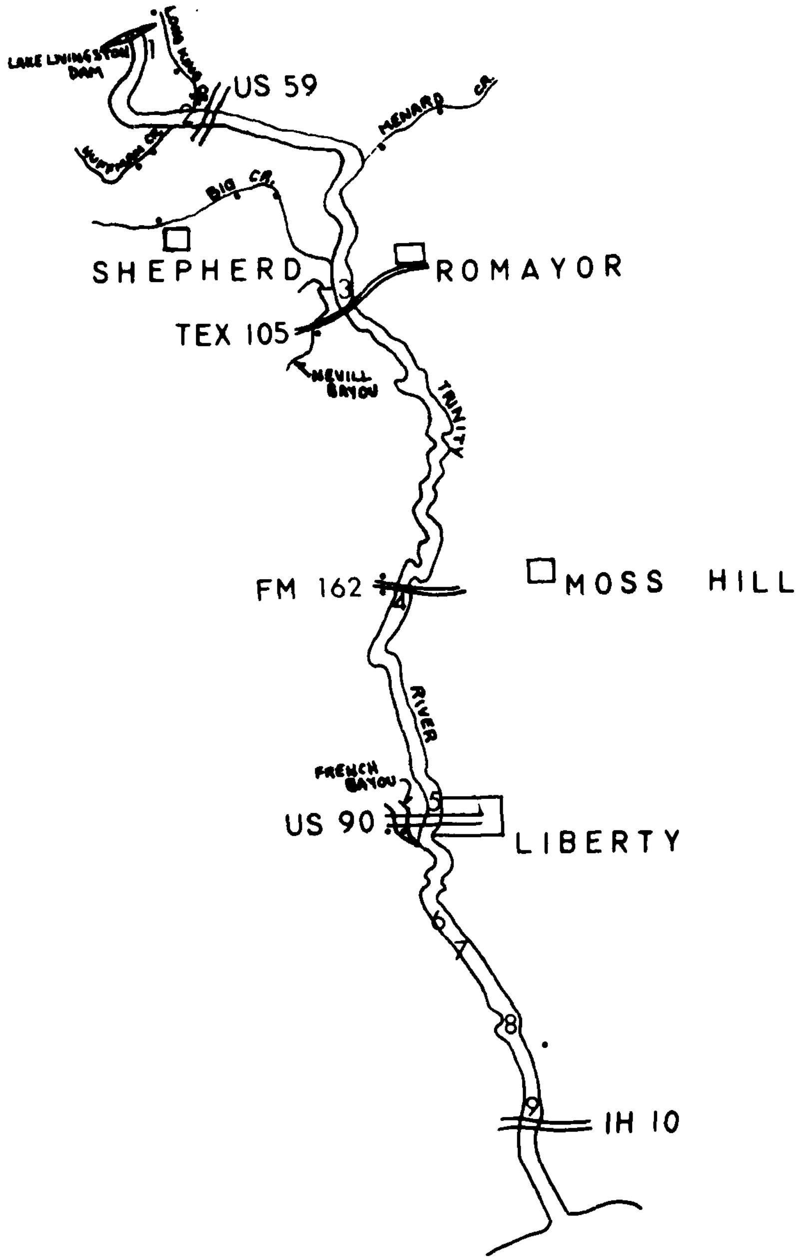

Figure 35. Map of Lower Trinity River Showing Collecting Stations

Fishes collected during this survey are listed by family, in Table 29, plus the 13 species listed by Lamb which we did not collect. Table 29 also includes recent records of anadromous marine fishes in the lower Trinity River.

The total number of fish species taken per station during this survey at each of the 9 sampling stations on the Trinity River proper is shown in Table 30. Stations are listed, in order, downstream from Lake Livingston Dam which is located on river mile 128.

Table 31 lists the total number of individuals of marine and brackish water fish species collected during this study by station. These species are listed, in order from Lake Livingston Dam downstream to Interstate Highway 10 bridge near Wallisville, Texas.

DISCUSSION

As noted previously, sampling techniques used during this study may have biased results somewhat in favor of small, streamlined, shallow water-zone species. Large gill nets were not available until the latter part of this survey and only then were certain large riverine species collected. In view of this, the data presented in Tables 29, 30, and 31 probably do not reflect the true relative abundance of fish species in the lower Trinity. In spite of the inherent shortcomings of the sampling gear, certain facts appear quite clear from our personal observations and the data at hand.

From this survey it is clear that: (1) Lake Livingston Dam acts as an efficient barrier to upstream migration of fishes, and because of the diversity of habitats immediately downstream the Trinity River supports a large and varied fish fauna. More than twice as many species were collected here than at any other station on the Trinity River mainstream (see Table 30).

(2) At least one fish species, the paddlefish, Polodon spathula, is either extremely rare or completely absent from the Trinity watershed. The factor or factors responsible for its disappearance are unknown.

(3) At least one undescribed, and possibly endemic, gar species (or undescribed gar hybrid) occurs in the lower Trinity River. To date little is known

Table 29. Inventory and Checklist of Fishes of the Trinity River Drainage System.

Species collected by Hall, Hammons, and Wiley, May-August 1972			
Family	Genus Species	Common Name	Number of Individuals
Lepisosteidae	Lepisosteus oculatus	Spotted gar	9
	Lepisosteus osseus	Longnose gar	1
	Lepisosteus sp.	Undescribed species or hybrid gar*	1
Amiidae	Amia calva	Bowfin	1
Clupeidae	Brevoortia gunteri	Bay menhaden	269
	Dorosoma cepedianum	Gizzard shad	199
	Dorosoma petenense	Threadfin shad*	1153
Engraulidae	Anchoa mitchilli	Bay anchovy*	107
Esocidae	Esox americanus	Grass pickerel*	9
Catostomidae	Ictiobus bubalus	Smallmouth buffalo	22
	Carpiodes carpio	River carpsucker	11
	Moxostoma congestum	Gray redhorse	3

Table 29. Continued

Family	Genus Species	Common Name	Number of Individuals
	Moxostoma poecilurum	Blacktail redhorse*	1
	Erimyzon sucetta	Lake chubsucker	9
Cyprinidae	*Cyprinus carpio*	Carp	2
	Notemigonus crysoleucas	Golden shiner	110
	Opsopoedus emilae	Pugnose minnow*	1
	Notropis fumeus	Ribbon shiner	40
	Notropis umbratilis	Redfin shiner	1
	Notropis shumardi	Silverband shiner*	1261
	Notropis texanus	Weed shiner*	1
	Notropis venustus	Spotted shiner	392
	Notropis lutrensis	Redhorse shiner	2249
	Notropis atrocaudalis	Blackspot shiner	11
	Notropis volucellus	Mimic shiner*	73
	Pimephales vigilax	Bullhead minnow	842

Table 29. Continued

Family	Genus Species	Common Name	Number of Individuals
Ictaluridae	*Ictalurus punctatus*	Channel catfish	9
	Ictalurus furcatus	Blue catfish	2
	Ictalurus melas	Black bullhead	19
	Ictalurus natalis	Yellow bullhead	86
	Pylodictis olivaris	Flathead catfish	1
	Noturus gyrinus	Tadpole madtom	1
	Noturus nocturnus	Freckled madtom*	55
Cyprinodontidae	*Fundulus grandis*	Gulf killifish*	104
	Fundulus pulvereus	Bayou killifish*	2
	Fundulus chrysotus	Redspot topminnow*	66
	Fundulus notti	Starhead topminnow*	52
	Fundulus notatus	Blackstripe topminnow	20
	Fundulus olivaceous	Blackspot topminnow	37
	Cyprinodon variegatus	Sheepshead minnow*	63

Table 29. Continued

Family	Genus Species	Common Name	Number of Individuals
Poeciliidae	Gambusia affinis	Mosquitofish	923
	Poecilia latipinna	Sailfin molly	84
Aphredoderidae	Aphredoderus sayanus	Pirate perch*	14
Mugilidae	Mugil cephalus	Striped mullet	145
Atherinidae	Menidia beryllina	Tidewater silverside*	291
	Labidesthes sicculus	Brook silverside*	56
Serranidae	Morone chrysops	White bass	1
	Morone mississippensis	Yellow bass	1
Centrarchidae	Micropterus punctulatus	Spotted bass	28
	Micropterus salmoides	Largemouth bass	100
	Chaenobryttus gulosus	Warmouth	30
	Lepomis cyanellus	Green sunfish	14
	Lepomis symmetricus	Bantam sunfish	15
	Lepomis punctatus	Spotted sunfish	42

Table 29. Continued

Family	Genus Species	Common Name	Number of Individuals
	Lepomis microlophus	Readear sunfish	29
	Lepomis macrochirus	Bluegill	172
	Lepomis humilis	Orangespotted sunfish	43
	Lepomis megalotis	Longear sunfish	169
	Lepomis marginatus	Dollar sunfish*	13
	Pomoxis annularis	White crappie	36
	Pomoxis nigromaculatus	Black crappie*	6
	Centrarchus macropterus	Flier	1
Elassomatidae	*Elassoma zonatum*	Banded pygmy sunfish*	9
Percidae	*Percina sciera*	Dusky darter	17
	Ammocrypta vivax	Scaly sand darter*	5
	Etheostoma chlorosomum	Bluntnose darter	5
	Etheostoma gracile	Slough darter*	1
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	4

Table 29. Continued

Family	Genus Species	Common Name	Number of Individuals
	Micropogon undulatus	Golden croaker*	16
Additional fish species reported by Lamb (1957) from the Trinity River which were *not* collected by Hall, Hammons, and Wiley.			
Lepisosteidae	*Lepisosteus spatula*	Alligator gar	
Characidae	*Astyanax fasciatus*	Banded tetra	1
Catostomidae	*Minytrema melanops*	Spotted sucker	4
Cyprinidae	*Phenacobius mirabilis*	Suckermouth minnow	?
	Notropis deliciosus (= *stramineus*)	Sand shiner	?
	Hybognathus nuchalis	Silvery minnow	6
	Hybognathus placita	Plains minnow	?
	Pimephales promelas	Fathead minnow	1
	Campostoma anomalum	Stoneroller	?
Centrarchidae	*Lepomis auritus*	Yellowbelly sunfish	1

Table 29. Continued

Family	Genus Species	Common Name	Number of Individuals
Percidae	*Percina caprodes*	Logperch	?
Additional fish species known to inhabit the lower Trinity River			
Anguillidae	*Anguilla rostrata*	American eel[1*]	
Sparidae	*Archosargus probatocephalus*	Sheepshead[1*]	
Clupeidae	*Alosa chrysochloris*	Skipjack herring[2*]	
Serranidae	*Morone saxatilis*	Striped bass[3*]	
Pleuronectidae	*Paralichthys lethostigma*	Southern flounder[4*]	

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[*] Species not reported by Lamb (1957) from the Trinity River.

[1] Personal communication, Mr. Lloyd Brannen, Commercial Fisherman, Liberty, Texas.

[2] Personal communication, Mr. Lloyd Hughes, owner: Damsite Marina, Goodrich, Texas.

[3] *The Lake Livingston Sportsman*, Newspaper, Livingston, Texas, May 27, 1972.

[4] *The East Texas Eye*, Newspaper, Goodrich, Texas, October 28, 1971, Vol. 3, No. 43, p. 1.

Table 30. Total Number of Fish Species Collected per Station on the Lower Trinity River

Station Number	Station Location	Total Number of Species Collected
1	1/4-1/2 mile downstream from Lake Livingston Dam	31
2	U. S. Highway 59 and the Trinity River near Goodrich, Texas	11
3	Texas State Highway 105 and the Trinity River near Romayor, Texas	13
4	Texas State Highway 162 and the Trinity River near Moss Hill, Texas	13
5	U. S. Highway 90 and the Trinity River at Liberty, Texas	14
6	5 miles downstream from Station #5 above	5
7	7 miles downstream from Station #5 above	14
8	Trinity River Authority Devers Pump Station near Moss Bluff, Texas	13
9	Interstate Highway 10 and the Trinity River near Wallisville, Texas	10

Table 31. Marine and Brackish Water Fish Species from the Lower Trinity River

Species	Trinity River below Lake Livingston Dam	Trinity River at U. S. 59	Trinity River at Texas State Highway 105 br.	Trinity River at State Highway 162	Trinity River at U. S. 90 Liberty, Texas	Trinity River 5 miles down from U. S. 90	Trinity River 7 miles down from U. S. 90	Trinity River Devers Pump Station	Trinity River at Interstate Highway 10
Cyprinodon variegatus							3	9	51
Fundulus grandis	6	1					6	9	83
Poecilia latipinna	1				5	2	17	54	3
Anchoa mitchilli					54		10	47	28
Brevoortia gunteri				2	9	211	22	2	23
Mugil cephalus	15	58	3	1	2		33		10
Menidia beryllina	27		15	1	13		46	19	170
Micropogon undulatus									16

regarding the taxonomic status, ecological requirements, or geographical range of this form.

(4) The lower Trinity River supports valuable sport and commercial fisheries of tremendous magnitude. Most sport fishing for such species as channel catfish, white bass, and largemouth bass occurs primarily from Lake Livingston Dam downstream to Liberty, Texas. Commercial fishing via hoop net, gill net, and trotline was observed throughout the entire lower Trinity River. Fishes taken by commercial fishermen include: gar, buffalo, freshwater drum, flathead catfish, carpsuckers, and carp.

(5) Forage fishes are extremely abundant in the Trinity River proper with redhorse shiners, silverband shiners and threadfin shad occurring in greatest numbers (see Table 29). Forage species occurring in lesser, but still significant numbers, include: bullhead minnow, spottail shiner, gizzard shad, tidewater silverside, bluegill sunfish and redear sunfish.

(6) A distinct gradient exists in the distribution of marine and estuarine fish species from the dam downstream. Excluding the extremely rare reports of striped bass and southern flounder taken at the dam in the Trinity River, the sequence (in regard to total number of marine and estuarine species collected per station) was 4, 3, 2, 3, 5, 2, 7, 6, and 8. Tidal influence is evident upstream to near Liberty, Texas. This, undoubtedly, accounts for the relatively large numbers of marine species taken at stations 5-9 which were within the tidal effect zone. Station number 6 was anomalous in that it consisted mainly of a backwater slough and is probably not a good indicator of the actual number of marine species in the adjacent Trinity mainstream.

(7) An ecotone effect is present in the lower end of the river downstream from Liberty, Texas where both marine and freshwater fish species are commonly taken together in seine hauls. This was not unexpected since many marine fishes have the ability to tolerate low salinities for varying periods of time. Undocumented reports of sand sharks, hammerhead sharks, pipefish, ribbon fish, and hardhead catfish in the lower Trinity lend credence to the idea that saltwater intrusion up the Trinity River may be responsible for the occurrence of these and other marine species far upstream.

(8) The three (or four) species of gar comprise the greatest fish biomass, by far, in the Trinity River system. This was noted by Lamb (1957) and holds true at present. Gar are currently caught and sold by commercial fishermen on the lower Trinity for 20¢/pound live weight or 40¢/pound dressed weight. Several tons of gar are taken each week in the lower Trinity River. Most of these are sold locally, while some are converted into fish sticks, fish cakes, etc., by processors as far away as California. Refrigerated vehicles are used to transport both buffalo and gar to distant processors.

(9) Apparently no rare and/or endangered fish species listed for Texas by Miller (1972) occur within the Trinity River drainage. Most of the species in the Trinity are widespread geographically and, for the most part, are quite tolerant of adverse ecological conditions.

Thus far this report has dealt only with the fishes present in the Trinity River system. Numerous biological, physical, and chemical factors influence the fish species composition of any body of water. It is axiomatic, therefore, that any drastic change in any or all of these factors is likely to favor some species to the exclusion of others. Stream canalization will probably produce marked changes in certain fish populations of the Trinity River.

As Rainwater (1972) has stated, artificial impoundment reduced flow, resulting in a situation which eventually produces a mud bottom and murky water. In many cases stratification of the water mass into three zones, the eip-, meta-, and hypolimnion, also occurs. Concomitant changes in fish populations occur as these conditions develop within a body of water. The crux of the matter, then, is not whether or not changes will occur with canalization, but whether these changes will be ultimately beneficial or detrimental to the fish fauna as a whole. Since much of the lower Trinity is at present characterized by mud bottom, sluggish flow, murky water, and saltwater intrusion, it appears unlikely that canalization will impose grossly detrimental effects on the fish populations extant in that portion of the river. Effects of canalization may be more pronounced upstream. Sport and game fishes are more abundant in the moderately swift-flowing portion of the Trinity from the dam downstream to Liberty, Texas than in the lower portion described above. Sand

and gravel substrates; flowing, generally clear water and numerous small tributaries are characteristic of the upper segment of the lower Trinity. Food and game fishes listed previously (page 299) are abundant in this portion of the river and their fate, after canalization, is debatable. Many of the riverine sport and food species can and will adapt to a lacustrine habitat, therefore, it is probable that canalization and concomitant impoundment of water will result in the rapid growth of certain desirable game and food fish populations. The overall effect, in long-term perspective, appears to favor the establishment and dominance of rough fish populations such as gar, buffalo, and carp.

The basic question lying at the heart of this problem is whether or not forage fish populations will be adversely affected by canalization. The aquatic food chain, obviously, determines which fish species will thrive and which will suffer. Only detailed, in-depth studies of water quality, food chain requirements, and forage fish populations will provide answers to the questions above.

Water quality will ultimately determine whether or not the food chain is capable of supporting viable fish populations. Water quality depends on a myriad of factors, not the least of which is the degree of industrialization and urbanization of the land areas adjacent to the canal, and the potential problems of pollution.

The problems in assessing the effects of artificial impoundments (and we interpret this to include canals) have been well-stated by Stroud (1969) who said, "Any attempt to broadly categorize reservoirs as mostly good or bad is likely to be a self-serving though futile exercise. There is no doubt that many reservoirs have directly inundated spawning areas and/or prevented or impeded successful passage of anadromous fishes to and/or from other ancestral spawning grounds. On the other hand, in economically depressed inland areas of the country, reservoirs have often served to create much new recreation opportunity and substantial new economic benefits as well as improved water supply. There are those, of course, who are so prejudiced against reservoirs that they can discern only environmental insult from reservoir construction. Equally, there are those who are so prejudiced in favor of reservoirs that they will admit of no detriment from their construction. It is very clear on balance, however, that reservoirs must be judged from a systems viewpoint, as well as individually."

To negate possible destructive effects of canalization on fish habitats Bayless and Smith (1971) suggested: (1) block off oxbow lakes to provide permanent ponds, (2) replace fish habitat destroyed with impounded water on an acre-for-acre basis, (3) construct small, deep ponds adjacent to channels as fish sanctuaries during low water periods, and (4) offset dredged channels from natural channels and maintain water in natural streambeds.

In conclusion, it appears that while certain detrimental effects may occur in certain fish populations, the overall beneficial effects will at least balance or perhaps exceed the detrimental effect _if_ sound fisheries management techniques and proper canal construction techniques are utilized.

SUMMARY

The Trinity River supports a rich and varied fish fauna comprised of at least 84 species. The majority of these are freshwater species, but numerous marine species are commonly found in the lower Trinity River basin. A gradient exists in the distribution of the marine species downstream from Lake Livingston Dam with relatively large numbers of marine species occurring from Liberty, Texas downstream to Trinity Bay.

Lake Livingston Dam acts as an efficient barrier to upstream migration of fishes and consequently provides a sport fishery of significant magnitude in the area immediately below the dam. A valuable commercial fishery for rough fishes also exists in the lower Trinity River.

No rare and/or endangered fish species are now recognized in the Trinity River drainage system. Most of the fish species extant in the system are widespread geographically and most are quite tolerant of adverse ecological conditions.

Changes in fish populations in the Trinity River will probably occur with canalization, but the detrimental effects will probably be exceeded by beneficial effects _if_ proper fisheries management techniques are used in the future and if proper canal construction techniques are used by the U. S. Army Corps of Engineers.

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CHAPTER VI

SUMMER BIRDS AND MAMMALS INHABITING THE TRINITY RIVER

by

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METHODS

The present investigation was carried out principally from mid-May to mid-July, 1972, but some of the data were gathered from February to May, 1972. Emphasis was placed on the middle and lower sections of the Trinity River, from Henderson and Navarro counties southward to the Liberty-Chambers county line.

For the purposes of this study the river was divided into three sections as follows: (1) upper river -- Riverside Drive in Fort Worth downstream to Highway 31 crossing (near Trinidad), total of 154 river miles; (2) middle river -- Highway 31 crossing downstream to Highway 19 crossing (south of Trinity), total of 208 river miles; and (3) lower river -- one mile below Lake Livingston Dam to the Liberty-Chambers county line, total of 126 river miles. All river miles are approximate, and were estimated from the Trinity River Authority watershed map published in April, 1971.

Data were gathered almost entirely from field surveys and censuses. These were conducted principally by boat, but some sites were also visited by vehicle, and on July 10 and 11 an aerial survey by heliocopter was made of the river from Tennessee Colony to Trinity Bay.

Mammals were surveyed by recording all evidence of their presence, sech as individuals trapped or sighted, dens, fecal remains, tracks, diggings, and partially eaten food. Trapping was limited to small mammals and was conducted on 12 different nights, each at a different site, by the use of museum special snap traps (similar to ordinary mouse or rat traps) with peanut butter as bait. About 50 traps were set per night. On two occassions bats were collected with a shotgun at dusk.

Data for birds were gathered by field observations and counts. All individuals of certain species (herons, egrets, kingfishers, and others) were counted during a complete traverse of the river by boat. For most birds, however, notes were kept only of their presence or absence and of their relative abundance. Relative abundance was determined, in part, by censuses of all species at more than a dozen selected sites scattered along the whole river. These counts were made for a three or four

hour period in the early morning, by a single observer who recorded all birds identified by either sight or song while he walked in a strip generally several hundred yards wide along the river bank. In addition, at four important nesting colonies, herons, egrets, ibises and other species were counted for a two-hour period prior to dark as they returned to the colony, thus giving an estimate of the kinds and numbers of birds utilizing each of these four nesting sites.

The focus of attention throughout this study was on populations inhabiting the water, shoreline, and adjacent bank areas of the river (generally within 1/4 mile of the river). More attention was paid to forest and woodland habitats than to fields, pastures, grasslands, or other open habitats. A majority of all data were therefore obtained from bottomland and hardwood forests.

In addition to the field surveys and censuses, a limited amount of information was gathered through conversations with local residents. Also, information available in the following published lists and species accounts of birds and mammals has been occasionally used in this report to supplement the field data: American Ornithologists Union (1957), Baker (1942; 1949; 1956), Blair, *et al.*(1968), Davis (1966), Griscom, *et al.*(1957), McCarley (1959), Peterson (1960), and Wolfe (1956).

RESULTS

Mammals

Species Present and Their Status

oppossum (*Didelphis marsupialis*): occurs rather commonly all along the river, frequenting a wide variety of habitats; tracks of this species were found irregularly along most of the river.

eastern mole (*Scalopus aquaticus*): apparently not very common, at least in bottomland forests; only rarely were the characteristic raised runways of this species encountered.

short-tailed shrew (*Blarina brevicauda*): probably distributed regularly in forest areas along the middle and lower river, but only one individual was trapped during the current study (on June 8 in northern Liberty County).

least shrew (*Cryptotis parva*): a grassland species, most likely occurring not uncommonly in suitable habitats

everywhere within the Trinity watershed, but it was not captured in the present inventory.

eastern pipistrel (*Pipistrellus subflavus*): primarily a forest species; frequently seen along the middle and lower river at dusk, foraging for insects over the water; specimens were collected at two localities, one in Madison and one in Liberty Counties.

big brown bat (*Eptesicus fuscus*): although this species is known to range throughout East Texas (Davis, 1966), it was not positively identified during this investigation, and must be relatively uncommon along the Trinity River.

red bat (*Lasiurus borealis*): probably of regular occurrence in forest areas everywhere along the river; this species was occassionally seen at dusk, and one speciment was collected in Liberty County.

seminole bat (*Lasiurus seminolus*): another forest species, reaching the western limit of its known range in extreme eastern Texas; not encountered in the present study, but there are specimens from Polk County, and the species probably occurs elsewhere along the lower Trinity River.

northern yellow bat (*Lasiurus intermedius floridanus*): according to Davis *(1966) this is a rare species in* Texas, but Barbour and Davis (1967) state that it is one of the most common bats in Florida; southeastern Texas is the western extremity of its known range, and a yellow bat which was collected during this study on June 20 above the mouth of Bedias Creek between Madison and Walker Counties is apparently one of the few specimens for the state.

evening bat (*Nycticeius humeralis*): not positively identified in the current inventory, but this species was probably one of the bats seen foraging over the river in forested areas at dusk; it is known to be common in parts of East Texas, and Dr. D. J. Schmidly of Texas A&M University (pers. comm.) stated that he has often netted this species along Catfish Creek in Anderson County.

eastern big-eared bat (*Plecotus rafinesquei*): not encountered in this study, but there are specimens of this bat from northern Polk County, where the first state record was taken in 1966 (Davis, 1966), and it therefore may be of rare occurrence on the lower and middle parts of the river.

Brazilian freetail bat (*Tadarida brasiliensis*, incl. "*cynocephala*" and "*mexicana*"): widespread in Texas and undoubtably breeding along many sections of the river, though no specimens or definite sightings were obtained in the present study.

armadillo (*Dasypus novemcinctus*): one of the most abundant mammals everywhere along the river; frequently seen in the daytime, and tracks and diggings of this species were found at almost every spot visited.

black-tailed jackrabbit (*Lepus californicus*): a western plains species reaching the eastern edge of its range along the upper and middle Trinity River, in non-forest habitats; this species was seen in Anderson County~~,~~ on the Coffield Prison Farm.

eastern cottontail (*Sylvilagus floridanus*): common along the whole river, principally in upland brushy habitats, but more often encountered on the upper and middle river than along the lower river; largely replaced by the following species in lowland habitats.

swamp rabbit (*Sylvilagus aquaticus*): abundant in bottomland forests along the middle and lower parts of the river; its presence was easily detected not only by the individuals flushed from thickets in the daytime, but also by the many conspicuous piles of fecal pellets found on top of logs.

gray squirrel (*Sciurus carolinensis*): common in floodplain forests and woodlands everywhere along the middle and lower regions of the river, as far upstream as Henderson and Kaufman Counties, but it was most frequently encountered between Anderson and Polk Counties; one of the principal game animals of this part of the state.

fox squirrel (*Sciurus niger*): one of the most abundant mammals along all sections of the river, inhabiting both upland and lowland forests; it was often seen, and leaf nests of this species (and the preceding) were frequently observed; a very popular game species, and of considerable economic importance.

southern flying squirrel (*Glaucomys volans*): resident in woodlands from the upper to the lower regions of the river, but owing to its nocturnal habits it was not often recorded; the high-pitched chattering notes of this species were occasionally heard at night.

thirteen-lined ground squirrel (*Citellus tridecemlineatus*): a grassland species of central and western Texas that has been recorded from Dallas and Navarro Counties (Davis, 1966), but it was not encountered in the current inventory.

plains pocket gopher (*Geomys bursarius*): uncommon to abundant in open upland situations with light soil, the conspicuous mounds of this species were found most often along the middle section of the river, usually well away from the river itself.

hispid pocket mouse (*Perognathus hispidus*): known to occur along all sections of the river, where it is an occupant of grassy upland habitats on sandy soil; no individuals were trapped during the present study.

beaver (*Castor canadensis*): a common inhabitant of the river all along its length, from lower Liberty County upriver at least as far as Kaufman County; beaver workings, dens, and tracks were among the mammal signs most frequently observed, although only on one occasion was an actual individual sighted.

long-tailed harvest mouse (*Reithrodontomys fulvescens*): a rather common rodent in grassy situations, both on upland and lowland sites; specimens were trapped along the river in Freestone, Houston, and Polk Counties.

eastern harvest mouse (*Reithrodontomys humulis*): reported to occur in deciduous forests as far west as southeastern Texas by Blair, *et al*. (1968), but this species was not found during the present study, and is apparently uncommon or rare in this part of its range.

deer mouse (*Peromyscus maniculatus*): a grassland and forest edge species which ranges eastward from central Texas to Dallas and Navarro Counties (Davis, 1966); it might occur locally in favorable habitats on the upper and middle river, but no specimens were obtained during this inventory.

white-footed mouse (*Peromyscus leucopus*): although this species is known to be a common resident of upland wooded areas throughout the state, it was not trapped during the current investigation.

cotton mouse (*Peromyscus gossypinus*): the most common small rodent encountered in bottomland forests; specimens were obtained at five different sites, all in Anderson and Liberty Counties.

golden mouse (*Peromyscus nuttalli*): a relatively uncommon forest rodent which occurs in the southeastern U. S. as far west as East Texas, specimens having been taken from Anderson and Trinity Counties (Davis, 1966): it was not found in this study, and is apparently uncommon or local along the Trinity.

pygmy mouse (*Baiomys taylori*): known to inhabit the eastern edge of the central Texas prairie region, and the upper coastal plain, but no specimens were obtained during the current investigation; it could occur, in small numbers, almost anywhere along the Trinity River.

northern rice rat (Oryzomys palustris): a rather small native rat inhabiting marshes and grasslands along the lower river, as far upstram as Walker and Trinity Counties (Davis, 1966); it was not encountered in this study.

hispid cotton rat (Sigmodon hispidus): one of the most abundant rodents along most sections of the river, preffering grassland and forest edge habitats, both in upland and low-lying areas; specimens were obtained at two localities (in Anderson and Freestone Counties), and their runways through the grass were observed on several other occasions; a widespread native rodent.

eastern woodrat (Neotoma floridana): nests of this large native rat were found commonly in Anderson County, but were not definitely observed elsewhere; the species is probably locally common along most sections of the river.

house mouse (Mus musculus): a small introduced rodent from the Old World which is widespread in North America; it is usually closely associated with human dwellings, but not infrequently it exists as a feral animal; a specimen was trapped in the present study from a bottomland forest in Anderson County.

roof rat (Rattus rattus): a large Old World rodent which is another commensal of man; widespread throughout most of the state, and an individual was trapped along the river in lower Liberty County during the present investigation.

Norway rat (Rattus norvegicus): known to occur widely in Texas, usually in close association with man; this introduced European species was not found in the present study.

nutria (Myocastor coypus): introduced from South America into the southern U. S., and now a common mammal in most of eastern Texas; this is a large semi-aquatic rodent which prefers quiet waters of ponds and marshes, or sluggish streams; it was found along the river only at two localities, one in Anderson County (where 6 individuals were seen together on the river bank) and one in Liberty County (where fecal pellets were discovered on the shore); poorly defined tracks suspected of belonging to this species were found on one or two occasions.

coyote (Canis latrans): a relatively common resident along most sections of the river, but not generally inhabiting the more extensive forest regions; tracks and "scats" of coyotes were found most commonly on the middle river, and several individuals were heard one night in Navarro County from a campsite across the river in Henderson County; almost all references to "wolves" by native East Texans pertain to this species.

red wolf (*Canis niger*): formerly ranged throughout East Texas, but now apparently confined to the upper coastal plain, where it is uncommon; it is probable that individuals of this species occasionally wander northward along the Trinity River into Liberty County; no positive evidence of this large canine was found during the present study.

red fox (*Vulpes fulva*): status uncertain; according to Blair (1966) this native American fox has been introduced at several localities in East Texas, but no certain signs of its presence were observed in this study.

gray fox (*Urocyon cinereoargenteus*): uncommon to common along the whole river, perhaps being most numerous in wooded areas of the middle river; tracks or scats of this species were identified at several localities.

ringtail (*Bassariscus astutus*): reported to occur fairly commonly along the upper parts of the river, at least as far south as Anderson County (Walt Daniel, pers. comm.); principally a semi-arid species of the Southwest; it was not encountered in the current inventory.

raccoon (*Procyon lotor*): common to abundant everywhere along the river; this species habitually forages along the shore, and its tracks were found more often that those of any other species.

long-tailed weasel (*Mustela frenata*): probably of rare occurrence in upland situations from the upper to the lower parts of the river, but no signs of this mammal were found in the current investigation.

mink (*Mustela vison*): occurs along all sections of the river, but it is apparently most numerous in wooded areas of the middle and lower river; tracks of this small carnivore were only occasionally identified along the river bank, but trappers reported it as common.

striped skunk (*Mephitis mephitis*): generally common on the middle and upper river, becoming less numerous along the lower river; prefers farmlands with scattered patches of woods; tracks of this species were regularly found, and not infrequently dead animals were seen along the highway.

spotted skunk (*Spilogale putorius*): this wide-ranging species is apparently only locally common in eastern Texas, and it was not recorded in the present inventory; according to McCarley (1959) it is present in open grassland situations interspersed with woodlands in Leon and Freestone Counties.

hog-nosed skunk (Conepatus mesoleucus): this southwestern species reaches the eastern extension of its range in Liberty and San Jacinto Counties (Davis, 1966); "rooter" skinks were not found in this study, though McCarley (1959) interviewed persons near Rye and Romayor who claimed to have seen them.

river otter (Lutra canadensis): apparently a rare and local resident of rivers and streams in East Texas; there are records from Polk and Chambers Counties along the lower river (Davis, 1966), and a Mr. Sturrock who was interviewed at Lake Charlotte (near the Liberty-Chambers County line) stated that he had seen their slides along the river in that area; however, no conclusive evidence of their presence was discovered during this investigation.

bobcat (Lynx rufus): uncommon in wooded areas along most of the river, but scarce along the upper river; frequently reported by local citizens as common, and tracks of this species were seen along the middle section of the river on several occasions during this investigation.

white-tailed deer (Odocoileus virginianus): locally abundant in wooded areas along the middle river from Henderson to Polk and Walker Counties; somewhat less common along the lower river; this species was particularly numerous in open floodplain forests, and its presence was often detected by its tracks and fecal pellets, as well as by sightings of individuals during the daytime (most often at dusk).

Small Mammal Trapping Success

The 12 sites where mammals were trapped, the date traps were set (all in 1972), and trapping success are as follows:

(1) February 3 - Polk County, 10 miles NW of Livingston, near Lake Livingston; 55 traps set; 2 Reithrodontomys fulvescens caught.

(2) March 4 - Houston County near the river, south of Highway 7 about 10 miles SW of Crockett; 60 traps set; 2 Reithrodontomys fulvescens caught.

(3) April 8 - Anderson County near the river, south of Highway 294 W of Elkhart; 70 traps set; 1 Peromyscus gossypinus and 1 Mus musculus caught.

Table 32. Summary of small mammal trapping success on the middle and lower Trinity River[a]

Species	Number of Individuals Caught				
	bottomland forest	forest edge	upland forest	grassland	TOTAL
Blarina brevicauda	1				1
Reithrodontomys fulvescens			1	4	5
Peromyscus gossypinus	9	1			10
Sigmodon hispidus		2		4	6
Mus musculus	1				1
Rattus rattus		1			1
Total individuals	11	4	1	8	24
Total traps set ("trap-nights")	428	64	78	53	623
Percent success	2.6	6.2	1.3	15.1	3.9

[a] Traps were set on 12 different nights, each at a different site, from February 3-July 8, 1972; see text for sites.

(4) May 2 - Anderson County, Keechi Creek about 7 miles W of Palestine; 48 traps set; 4 *Sigmodon hispidus* caught.

(5) June 6 - Polk and San Jacinto Counties, along both sides of the river about 5 river miles below Lake Livingston Dam; 50 traps set; nothing caught.

(6) June 8 - Liberty County, north side of the river about 3 miles NW of Romayor; 50 traps set; 1 *Blarina brevicauda* and 3 *Peromyscus gossypinus* caught (plus 4 *Pipistrellus subflavus* and 1 *Lasiurus borealis* shot at dusk).

(7) June 9 - Liberty County, on right side of the river in the Tanner Bayou area just above Mud Lake; 50 traps set; 2 *Peromyscus gossypinus* caught.

(8) June 14 - Liberty County, right side of the river about 4 miles NW of Moss Bluff; 50 traps set; 2 *Peromyscus gossypinus* caught.

(9) June 15 - right side of the river just below the Liberty-Chambers county line; 50 traps set; 1 *Peromyscus gossypinus* and 1 *Rattus rattus* caught.

(10) June 20 - Madison County, just above the mouth of Bedias Creek; 50 traps set; nothing caught (1 *Pipistrellus subflavus* and 1 *Lasiurus intermedius* shot at dusk).

(11) July 3 - Anderson and Freestone Counties, both sides of the river at Coffield Prison Farm (near damsite 2A); 50 traps set; 1 *Peromyscus gossypinus*, 1 *Reithrodontomys fulvescens*, and 2 *Sigmodon hispidus* caught.

(12) July 8 - Leon County, right side of river about 2 miles below Highway 7; 50 traps set; nothing caught.

These results are summarized in Table 32 .

Birds

Species Present and Their Status

anhinga (*Anhinga anhinga*): Uncommon to common on the middle and lower river, inhabiting sloughs, swamps, oxbow lakes, and the river itself, as far north as Anderson County.

great blue heron (*Ardea herodias*): occurs regularly and fairly commonly on all sections of the river, frequently foraging on the mudbanks and sanbars of the river.

green heron (*Butorides virescens*): common on most parts of the river, but somewhat less numerous on the upper and extreme lower river; a solitary species often seen on smaller streams as well as on the river.

little blue heron (*Florida caerulea*): common to abundant on all sections of the river; many juvenal birds seen in July; forages along the shores of the river, streams, lakes, and marshes, and occasionally in open fields; gregarious in nesting, usually in company with cattle egrets.

cattle egret (*Bubulcus ibis*): abundant everywhere along the Trinity, nesting in large colonies in the middle of swamps; unlike other related species the cattle egret forages primarily in open fields and pastures, usually around domestic livestock (principally cattle).

common egret (*Casmerodius albus*): uncommon to common on the middle and lower river, and rare on the upper river; utilizes the shore of the river for foraging, but most numerous in marshes and around lakes (such as upper Lake Livingston and just below the Lake Livingston dam).

snowy egret (*Leucophoyx thula*): uncommon along most sections of the river, where it feeds on the sandbars and mudbanks.

Louisiana heron (*Hydranassa tricolor*): common along the extreme lower part of the river during the breeding season, wandering northward uncommonly to the middle and upper parts of the river in late summer; only once observed foraging on the shore of the river itself.

black-crowned night heron (*Nycticorax nycticorax*): very rare along the river itself, but breeding in small numbers in some of the swamps and oxbox lakes back from the river.

yellow-crowned night heron (*Nyctanassa violacea*): occurs regularly in small numbers all along the river, being rather solitary in its foraging and nesting habits; many juvenals seen in July.

wood ibis (*Mycteria americana*): an uncommon to common post-breeding wanderer which occurs all along the river but it is more numerous on the lower river; not seen foraging along the river itself; individuals were first seen in mid-June.

white ibis (*Eudocimus albus*): common on the lower river, becoming uncommon to rare on the middle river; prefers marshes, swamps, and oxbow lakes back from the river for feeding.

roseate spoonbill (*Ajaia ajaja*): a species of the coastal marshes which is rather rare on the extreme lower Trinity River; a few individuals wander northward after the breeding season, and a single bird was seen on the shore of the river in northwestern Henderson County on June 27.

wood duck (*Aix sponsa*): an uncommon to common breeder in the sloughs, swamps, and oxbow lakes all along the river, occasionally foraging on the river itself; young birds were seen on the upper and middle river in early July.

turkey vulture (*Cathartes aura*): common to abundant everywhere along the river, not infrequently feeding on carrion on the river bank.

black vulture (*Coragyps atratus*): distritubtion and habits similar to the above species, with which it usually associates, but it is never as numerous.

Mississippi kite (*Ictinia misisippiensis*): occurs uncommonly but regularly along the lower river, in Polk, San Jacinto, and Liberty counties; a total of 13 individuals were seen; feeds primarily on insects caught on the wing, often over the river; this species was not previously known to be a summer resident in this part of the state.

red-tailed hawk (*Buteo jamaicensis*): fairly common in open areas along the upper river, becoming scarcer farther south, and not seen on the lower river.

red-shouldered hawk (*Buteo lineatus*): a common resident on all sections of the river, preferring wooded areas; many juvenals seen in July.

broad-winged hawk (*Buteo platypterus*): only one record, a bird seen near Elkhart in Anderson County on May 30; known to breed locally in wooded areas throughout most of East Texas.

osprey (*Pandion haliaetus*): apparently a rare summer resident on at least the lower river; one bird was seen along a several mile stretch of the river between Lake Livingston and Hwy 59 on June 8, and another individual was observed flying over the river several miles south of Hwy 162 in Liberty County on June 9; it is not known whether these birds were breeding or not.

sparrow hawk (*Falco sparverius*): prefers open areas; only one record, a bird in Polk County on June 5.

bobwhite (*Colinus virginianus*): rather uncommon on the upper and middle river, and rare on the lower river, inhabiting open upland fields and brushy areas.

gallinule (*Porphyrula martinica* or *Gallinula chloropus*): only one record, a bird which was heard calling from an oxbow lake near the river in Liberty County; both species are known to breed locally in east Texas.

killdeer (*Charadrius vociferus*): uncommon to common almost everywhere along the river, often foraging on sandbars and mudbanks, but prefers open fields and pastures.

spotted sandpiper (*Actitis macularia*): not a breeding bird in Texas but late spring migrants almost overlap early fall migrants (perpahs some nonbreeding birds remain during the summer); forages on sandbars and mudbanks of the river; individuals were seen as late as May 25, and as early as July 8.

mourning dove (*Zenaidura macroura*): common in open areas throughout the length of the river; often flies to the river to drink in late afternoon.

yellow-billed cuckoo (*Coccyzus americanus*): very common in wooded areas from the upper to the lower river; frequently seen flying across the river.

roadrunner (*Geococcyx californianus*): uncommon to rare in all sections, inhabiting forest edges and open brushy areas.

barn owl (*Tyto alba*): not found during the present inventory, but one bird was seen along the river in Anderson County on Oct. 8, 1971 by Dr. E. S. Nixon; possibly a rare woodland resident locally along some sections of the river.

screech owl (Otus asio): a nocturnal species known to inhabit both upland and lowland forests in east Texas; not recorded on this study, probably due to its quietness at this time of year (the non-breeding season) and the difficulty of flushing birds from their roosting hollows during the daytime.

great horned owl (Bubo virginianus): fairly common on the upper river, where it was seen during the daytime in trees and wooded areas along the river; less abundant on the middle river, and not recorded at all from the lower river; prefers more open areas and upland situations than the following species.

barred owl (Strix varia) : common to very common in lowland forests along the whole length of the river; frequently heard at night, and occasionally seen in the daytime.

chuck-will's-widow (Caprimulgus carolinensis): a nocturnal forest species which breeds uncommonly to commonly along the middle and upper river; recorded in this study only from Anderson and Walker counties.

common nighthawk (Chordeiles minor): locally common along most sections of the river, in open situations and around towns.

chimney swift (Chaetura pelagica): common to abundant everywhere along the river, foraging for aerial insects high in the sky, and occasionally low over the river.

ruby-throated hummingbird (Archilochus colubris): an uncommon woodland and forest edge species on all parts of the river.

belted kingfisher (Megaceryle alcyon): occurs along the entire river, but more numerous on the lower river than elsewhere; feeds on small fish and nests in holes in vertical banks of the river.

yellow-shafted flicker (Colaptes auratus): known to breed locally in east Texas, preferring open situations with scattered trees, but not recorded in the current inventory.

pileated woodpecker (Dryocopus pileatus): an uncommon to common resident along the lower and middle river at least

as far north as Henderson County; inhabits both upland and bottomland forests.

ivory-billed woodpecker (*Campephilus principalis*): formerly occurred in bottomland forests of east Texas as far west as the Trinity River; there are more than a dozen reported sightings of this species from the "Big Thicket" area in the past decade (all from the Neches watershed), but none have been substantiated by any positive evidence, causing many ornithologists to consider the bird extinct in Texas; during the present inventory, on July 12, a large woodpecker was seen by Lin Risner flying along the west bank of the river several miles south of Hwy 162, in the Tanner Bayou area of Liberty County; the description of the bird and the field sketch are that of an ivory-billed woodpecker.

red-bellied woodpecker (*Centurus carolinus*): the most abundant woodpecker everywhere along the river; it was frequently seen flying across the river.

red-headed woodpecker (*Melanerpes erythrocephalus*): locally common along most parts of the river, preferring more open areas than most related species.

hairy woodpecker (*Dendrocopus villosus*): recorded in the present study only from the middle river, where it was uncommon.

downy woodpecker (*Dendrocopus pubescens*): uncommon to common in wooded areas along all of the river.

red-cockaded woodpecker (*Dendrocopus borealis*): a very local species of mature open pine forests in east Texas; recently found to occur in the Brushy Creek area of Trinity County north of Onalaska, near Lake Livingston.

eastern kingbird (*Tyrannus tyrannus*): fairly common in open situations along the entire length of the river.

western kingbird (*Tyrannus verticalis*): a western plains species reaching the Trinity River only in Dallas, Ellis, and Navarro counties; a nest was found on June 28 in Navarro County in open farmland about 6 miles from the river.

scissor-tailed flycatcher (*Muscivora forficata*): common in open habitats everywhere along the river.

great crested flycatcher (*Myiarchus crinitus*): uncommon to common in forests and woodlands from the upper to the lower river.

eastern phoebe (*Sayornis phoebe*): recorded in the current study only from Anderson County, at two localities along Catfish Creek.

acadian flycatcher (*Empidonax virescens*): uncommon to common in mature open woodlands and forests from Liberty County northward at least as far as Henderson County.

eastern wood pewee (*Contopus virens*): fairly common in wooded areas along the entire river.

horned lark (*Eremophila alpestris*): a prairie and open grassland species of central and western Texas which was recorded in this study only from the Coffield Prison Farm in Anderson County (4 birds on June 29).

rough-winged swallow (*Stelgidopteryx ruficollis*): uncommon to common along the whole river, frequently foraging for insects over the river, and nesting in holes and crevices in vertical banks.

barn swallow (*Hirundo rustica*): locally common in open areas along the upper and middle river, but rare on the lower river (one record only).

cliff swallow (*Petrochelidon pyrrhonota*): common along the river in Dallas County, but not recorded elsewhere.

purple martin (*Progne subis*): locally common in open habitats and urban areas along all sections of the river; occasionally seen foraging over the river.

blue jay (*Cyanocitta cristata*): uncommon on the lower part of the river, becoming somewhat more numerous on the middle and upper river, in wooded habitats and in towns.

common crow (*Corvus brachyrhynchos*) : common everywhere along the river; often seen drinking on the shore of the river in late afternoon.

Carolina chickadee (*Parus carolinensis*): very common in upland and wetland forests along the whole river.

tufted titmouse (*Parus bicolor*): very common in all wooded habitats everywhere along the river, often associating with the above species.

white-breasted nuthatch (*Sitta carolinensis*): uncommon in floodplain forests of the middle river, from Henderson to Walker counties.

brown-headed nuthatch (*Sitta pusilla*): confined to the open pine forests of East Texas; recorded in this study only from Polk County west of Livingston.

Carolina wren (*Thryothorus ludovicianus*): common to abundant in forest areas everywhere along all sections of the river; one of the most conspicuous avian species.

mockingbird (*Mimus polyglottos*): common to abundant in open habitats along the entire length of the river, but less numerous along the lower river.

brown thrasher (*Toxostoma rufum*): only one record, a single bird on Coffield Prison Farm in Anderson County on July 3.

catbird (*Dumutella carolinensis*): an uncommon local summer resident; recorded only from Anderson, Madison, and Liberty Counties.

robin (*Turdus migratorius*): recorded only twice, on June 2 in Livingston (Polk County) and on July 7 in Athens (Henderson County); prefers towns and cities.

wood thrush (*Hylocichla mustelina*): an uncommon to rare forest species along the middle and lower river.

eastern bluebird (*Sialia sialis*): common locally in open habitats along the upper and middle river; not recorded from Liberty County.

blue-gray gnatcatcher (*Polioptilla caerulea*): uncommon to common in wooded areas along all sections of the river.

loggerhead shrike (*Lanius ludovicianus*): rather uncommon in open habitats along the upper and middle river; not recorded in this investigation from any area along the lower river.

starling (*Sturnus vulgaris*): uncommon to common around towns along the entire river, but only very rarely seen along the river itself or in rural habitats; abundant in the Dallas-Fort Worth area.

white-eyed vireo (*Vireo griseus*): common in forests, woodlands, and brushy areas everywhere along the river, but apparently less common on the upper river than elsewhere.

yellow-throated vireo (*Vireo flavifrons*): uncommon in upland and lowland forests from Liberty County at least as far north as Anderson County.

red-eyed vireo (*Vireo olivaceus*): common in forests along the entire river.

warbling vireo (*Vireo gilvus*): apparently a rare and local summer resident from the lower to the upper river, preferring small open stands of tall cottonwoods; it was recorded only twice during the present study, in Polk County (where a nest was found and several singing males were heard) and in Liberty County; the species has been reported nesting in Dallas County.

black & white warbler (*Mniotilta varia*): recorded only along the middle river, from Anderson to Polk Counties, where it was uncommon; prefers upland mixed forests.

prothonotary warbler (*Protonotaria citrea*): uncommon to common along the middle and lower river, inhabiting swamps, sloughs, and willows along the river shore; reported to breed rarely in Dallas County, but not found along the upper river in this study.

Swainson's warbler (*Limnothlypis swainsonii*): occurs regularly and fairly commonly in suitable habitats along the lower and middle river, from Liberty County to Anderson County; prefers lowland wooded areas with a dense woody undergrowth (particularly cane).

parula warbler (*Parula americana*): the most abundant woodland warbler everywhere along the river, but it was usually found only where Spanish moss was present; it was not recorded north of Anderson County.

yellow warbler (*Dendroica petechia*): only one record, a singing male at Highway 105 bridge in Liberty County on June 9; this is south of the known breeding range of this species in East Texas; the individual heard may have been unmated or possibly a very late migrant.

yellow-throated warbler (*Dendroica dominica*): rather rare and local along the middle and lower river; prefers upland mixed forests or very open floodplain forests, almost always near water; recorded from Anderson, Freestone, Houston, and Liberty Counties.

pine warbler (*Dendroica pinus*): confined to pine forests; recorded from Freestone, Polk, and Liberty Counties; only at a few points along the middle and lower river are suitable habitats found adjacent to the river.

prairie warbler (*Dendroica discolor*): rare and local in upland open brushy habitats along the middle river; found only in Anderson and Polk Counties.

Louisiana waterthrush (*Seiurus motacilla*): local and uncommon along small permanent streams from Anderson to Liberty Counties; this species was not found on the river itself.

Kentucky warbler (*Oporornis formosus*): uncommon to common in both upland and bottomland forests of the middle and lower river.

yellowthroat (*Geothlypis trichas*): rather uncommon along the upper and middle river, becoming rare on the lower river; a species of wet thickets and the edge of marshes, mostly in open situations.

yellow-breasted chat (*Icteria virens*): generally common in thickets, brushy areas, and overgrown fields on all sections of the river.

hooded warbler (*Wilsonia citrina*): found only in mature bottomland forests with a fairly dense woody understory; common in favorable habitats along the lower river, becoming less numerous and uncommon to rare on the middle river; recorded as far north as Anderson County.

American redstart (*Setophaga ruticilla*): a fairly common summer resident in mature bottomland forests along the lower river in Liberty County; more than 30 records between May 24 and July 13; this species was not previously known from this part of the state during the summer months; also recorded from Anderson County (Catfish Creek) on May 30.

house sparrow (*Passer domesticus*): uncommon to abundant along all sections of the river, but usually found only around towns, cities, and human habitations; occasionally found nesting under highway bridges over the river.

eastern meadowlark (*Sturnella magna*): generally common to abundant in open grassy fields and pastures everywhere along the river, but somewhat less numerous on the lower river.

red-winged blackbird (*Agelaius phoeniceus*): common to abundant locally along all sections of the river, preferring open areas with marshes or wet grasslands and thickets.

orchard oriole (Icterus spurius): uncommon to common along the whole river; prefers open situations such as forest edges, farmlands, and trees along the river.

Baltimore oriole (Icterus galbula): only one record, a bird heard singing along the river at Moss Bluff in Liberty County on May 25.

boat-tailed grackle (Cassidix mexicanus): abundant in Dallas County, becoming uncommon to rare southward, as far as Anderson County; inhabits open fields, marshes, and the edge of lakes.

common grackle (Quiscalus quiscula): uncommon to common locally along all sections of the river; frequents open areas, particularly around towns and human habitations.

brown-headed cowbird (Molothrus ater): very common in most habitats throughout the length of the river, but occurs less frequently in bottomland forests than elsewhere.

summer tanager (Piranga rubra): rather uncommon but widespread in forests and woodlands from the upper to the lower river; probably somewhat more numerous on upland sites than in the river floodplain.

cardinal (Richmondena cardinalis): abundant everywhere along the river, preferring forests, thickets, and woodland edges; often the most numerous species present.

blue grosbeak (Guiraca caerulea): recorded only from the middle river, from Anderson to Polk Counties, where it was uncommon; known to breed in Dallas County, and probably a rather rare summer resident also on the lower river; inhabits thickets,brushy areas, and woodland edges.

indigo bunting (Passerina cyanea): common to abundant on all sections of the river, frequenting forest clearings, woodland edges, thickets, and brushy habitats.

painted bunting (Passerina ciris): very similar to the above species in distribution and abundance; these two buntings were often found together, and along non-forested parts of the river they frequently were the most conspicuous avian species; in general the indigo bunting was the more common of the two on the upper river, and the painted bunting the more numerous on the lower river.

dickcissel (Spiza americana): common locally in open fields on the upper and middle river, as far south as Polk County.

American goldfinch (Spinus tristis): one record, a pair of birds in breeding plumage seen along the river in Anderson County on June 29.

lark sparrow (Chondestes grammacus): fairly common on the upper part of the river in open fields and pastures and along roadsides; less numerous and somewhat local on the middle river and not found south of Polk County.

grasshopper sparrow (Ammodramus savannarum): rather rare and local in open grassland habitats on the upper river, south at least as far as Anderson County.

Bachman's sparrow (Aimophila aestivalis): known to be a local summer resident in East Texas in old fields and open pine woodlands; not recorded in the current inventory, but a singing male was heard in Polk County on June 5, 1971, at a site 4 miles west of Moscow.

chipping sparrow (Spizella passerina): breeds locally in open pine forests in East Texas; recorded only from Polk County in this study.

field sparrow (Spizella pusilla): only one record, a bird seen in Freestone County on July 3, across the river from Coffield Prison Farm; inhabits old fields and weedy pastures.

Nesting Sites and Censuses of Herons, Egrets Ibises, and Associated Species

Certain species of large wading and water birds characteristically nest gregariously in mixed colonies or "heronries." In East Texas these nesting colonies are almost always situated in the middle of a small to large swamp where there is a dense growth of shrubs (usually buttonbush, Cephalanthus occidentalis); often there are also scattered tall trees present, such as cypress (Taxodium distichum) and tupelo gum (Nyssa aquatica). Nests are built in the shrubs and trees at all heights above the water. The number of birds nesting in suitable swamps is frequently limited by the number of nest sites available. Oxbow lakes and swamps with only open water in the middle, or without small woody vegetation (i.e., shrubs), are not usually chosen as nesting sites, at least by the two species--cattle egret and little blue heron--which characteristically make up the majority of individuals in the large East Texas colonies. Therefore, nesting colonies tend to be rather widely scattered owing to the relative unavailability of preferred sites. In

the present inventory only three large heronries and one smaller colony were located and censused. Another relatively small colony was located but not censused. There are undoubtedly other important nesting sites along the Trinity River and small heronries with only a few hundred birds or less are probably of regular occurrence. All of the heronries censused in the present inventory are within 5 miles of the river.

Census results for the four colonies are shown in Table 33 . It should be pointed out that these figures underestimate the total populations utilizing the sites for breeding or nesting, since all the individuals in a colony cannot be expected to have passed over the four observers during the two-hour census periods. Some individuals, particularly of the anhinga, green heron, and two species of night herons, probably forage in or near the swamp utilized for nesting, and would thus not be counted by observers stationed away from the swamp. Night herons were counted as they left the colony, rather than as they returned. The figures listed are for adult birds only, as well as could be determined, but it cannot be assumed that they all necessarily represent breeding birds, since some non-breeding individuals could utilize the colony only for roosting purposes. The wood ibises were almost certainly post-breeding visitors to the two lower river colonies and this is probably also true of the 4 spoonbills at the Old River heronry.

The cattle egret was always the most numerous species present, often overwhelmingly so. On the middle river the little blue heron was the second most abundant species, but on the extreme lower portion of the river the white ibis ranked as the second most numerous species. These three species comprised from 87-97 percent of all individuals in all four colonies. The tremendous increase and spread of cattle egrets in Texas since its first occurrence in the state in 1955 (Wolfe, 1956) is of major ornithological significance.

Use of the Trinity River for Foraging by Large Wading and Other Birds

A dozen or so relatively common breeding birds (Table 34) directly utilize the shore and water of the Trinity River for obtaining food. These species as a whole feed primarily on small aquatic and shoreline invertebrates and small to medium-sized fish. One species (the wood duck) consumes primarily aquatic vegetation, as well as

Table 33. Estimates of breeding populations of herons, egrets, ibises and other birds at known nesting colonies along the Trinity River[a]

Species	Total Individuals (left) and Percent of Total Population (right)							
	site 1[b]		site 2[c]		site 3[d]		site 4[e]	
anhinga	24	0.2	26	1.1	10	1.6	100*	1.5
great blue heron	9	0.1	8	0.3	5	0.8	50*	0.8
green heron	10	0.1	14	0.6	2	0.3	1	0.0
little blue heron	995	10.4	340	14.5	78	12.8	335*	5.1
cattle egret	8389	87.9	1882	80.2	268	44.1	4219	64.0
common egret	50	0.5	36	1.5	26	4.3	61	0.9
snowy egret	21	0.2	13	0.5	1	0.2	5	0.1
Louisiana heron	0	0.0	0	0.0	1	0.2	266	4.0
b-c night heron	9	0.1	3	0.1	0	0.0	3	0.0
y-c night heron	27	0.3	17	0.7	28	4.6	17*	0.3
wood ibis	0	0.0	0	0.0	3	0.5	7	0.1
white ibis	10	0.1	9	0.4	186	30.6	1526	23.1
roseate spoonbill	0	0.0	0	0.0	0	0.0	4	0.1
Total	9544	99.9	2348	99.9	608	100.0	6594	100.0

Table 33. Continued

[a] Each census was conducted bysstationing 4 observers roughly in a circle around the resting colony, at distances of 1/2-3 miles away from the swamp where it was situated; birds were counted as they returned to the colony during the 2 hour period prior to dark. The figures listed are for adult birds only.

[b] Sand Pond heronry (Anderson County, 3 miles NW of Tennessee Colony); July 4, 1972.

[c] Goodrich heronry (lower Polk County, 1 1/2 miles SE of Goodrich); June 21, 1972.

[d] Tanner Bayou heronry (upper Liberty County, 1 mile S of Highway 162 bridge); July 12, 1972.

[e] Old River heronry (lower Liberty County, 2 miles NE of Old River); July 13, 1972.

*These figures were obtained by counting birds in the colony itself early on the morning of July 27, and all are somewhat higher than the figures for the evening count on July 13.

Table 34. Summer census of avian species utilizing the shores and water of the Trinity River for feeding[a]

	Total individuals (left) and birds per river mile (right)											
Species	section 1[b]		section 2[c]		section 3[d]		section 4[e]		section 5[f]		section 6[g]	
anhinga	0	0.00	0	0.00	0	0.00	13	0.27	35	0.60	14	0.23
great blue heron	11	0.18	25	0.32	20	0.24	4	0.08	22	0.38	11	0.18
green heron	4	0.07	3	0.04	16	0.19	15	0.31	15	0.26	4	0.07
little blue heron	46	0.77	70	0.90	100	1.20	14	0.29	40	0.69	13	0.21
cattle egret	5	0.08	4	0.05	2	0.02	4	0.08	5	0.09	7	0.11
common egret	1	0.02	0	0.00	5	0.06	16	0.33	7	0.12	11	0.18
snowy egret	1	0.02	2	0.03	9	0.11	7	0.14	32	0.55	13	0.21
y-c night heron	3	0.05	8	0.10	13	0.16	2	0.04	6	0.10	6	0.10
wood duck	9	0.15	7	0.09	4	0.05	0	0.00	2	0.03	3	0.05
osprey	0	0.00	0	0.00	0	0.00	0	0.00	1	0.02	1	0.02
killdeer	26	0.43	30	0.38	13	0.16	1	0.02	5	0.09	5	0.08
belted kingfisher	1	0.02	3	0.04	2	0.02	5	0.10	18	0.31	6	0.10

Table 34. Continued

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[a] river censused by proceeding downstream in a boat at an average speed of approximately 10-12 mph; census dates June 8-July 9, 1972.

[b] Highway 34 to Highway 31 (60 river miles).

[c] Highway 31 to Highway 79/84 (78 river miles).

[d] Highway 79/84 to Highway 21 (83 river miles).

[e] Highway 21 to Highway 19 (48 river miles).

[f] One mile below Lake Livingston dam to Highway 162 (58 river miles).

[g] Highway 162 to 3 miles above Interstate Highway 10 (61 river miles).

seeds and nuts obtained on shore. Due to differences in size and kind of food taken, manner of captureing food, and particular part of the shore or river utilized, these species inhabit different foraging niches, and successfully divide up the available food resources among themselves. This has been indicated at the family level in Table 35, which in addition to the species listed in Table 34, also includes data for the rough-winged swallow (family Hirundinidae) and three species of hawks (red-tailed hawk, red-shouldered hawk, and Mississippi kite, all in the family Accipitridae); the anhinga is in the family Anhingidae, all herons and egrets in the Ardeidae, the wood duck in the Anatidae, the osprey in the Pandionidae, the killdeer in the Charadriidae, and the kingfisher in the Alcedinidae.

Since a given point on the river was censused only at a particular instant of time, it is obvious that the data in Tables 34 and 35 do not represent the total numbers of individuals utilizing the river for foraging during the summer (or even during a day), but merely allow very crude comparisons of one section of the river with another section. In this regard the following facts seem evident: (1) there are few striking differences between the upper, middle, and lower sections of the river (though it should be remembered that only the lower part of the upper river was censused by boat); (2) in comparing birds per river mile, rough-winged swallows were least abundant but killdeer and wood ducks were most abundant on the upper river, red-tailed and red-shouldered hawks were most abundant on the middle river, and anhingas and kingfishers occurred most frequently along the lower river; (3) at the family level, herons and egrets were fairly uniformly distributed along all sections of the river, though they were slightly less numerous on the upper river; (cattle egrets were counted only when they were seen feeding on the shore near the water, with or without the presence of cattle).

The above figures reflect many factors, including time of day of the census, stage of breeding season, food abundance and quality, availability of suitable mudbanks and sandbars, nearness to breeding sites, and water level of the river. The data must, therefore, be interpreted very cautiously. It is suspected, for instance, that the somewhat larger number of wood ducks per mile on the upper river is in part because adults were on the river with young at the time of year (early July) that this part of the river was censused, and also because fewer suitable habitats for this species are available away from the river in this area than on the middle and lower parts of the river.

Table 35. Relative use of the Trinity River for foraging by various families of birds during the breeding season[a]

Family[b]	Feeding Niche	Total individuals (left) and birds per river mile (right)					
		upper river[c]		middle river[d]		lower river[e]	
Anhingidae (1)	deep water fish	0	0.00	13	0.06	49	0.39
Ardeidae (7)	shoreline and shallow water invertebrates and fish	71	1.18	339	1.63	192	1.52
Anatidae (1)	seeds, nuts, aquatic plants	9	0.15	11	0.05	5	0.04
Accipitridae (3)	small terrestrial vertebrates and large insects	7	0.12	50	0.24	19	0.15
Pandionidae (1)	medium-sized fish near the surface	0	0.00	0	0.00	2	0.02
Charadriidae (1)	small shoreline invertebrates	26	0.43	44	0.21	10	0.08
Alcedinidae (1)	small fish near the surface	1	0.02	10	0.05	24	0.19
Hirundinidae (1)	aerial insects	1	0.02	65	0.31	38	0.30

[a] River censused by proceeding downstream in a boat at an average speed of approximately 10-12 mpg; census dates June 8-July 9, 1972.

[b] Parentheses indicate the number of species involved in each family.

[c] Highway 34 to Highway 31 (60 river miles). [d] Highway 31 to Highway 19 (208 river miles).

[e] One mile below Lake Livingston dam to 3 miles above Interstate Highway 10 (126 river miles).

DISCUSSION

Rare, Endangered, and Endemic Species

black bear (Ursus americanus): this species was once widespread in Texas, but now is found only in small numbers in the western mountains (Davis, 1966). According to Baker (1956) bears persisted in East Texas at least until the 1930's, and there are a few later reports from Tyler, Polk, Angelina, and Nacogdoches Counties. In the current survey no evidence of bears was found and they were not reported to the investigators by any local resident. It is therefore very unlikely that this species now exists anywhere along the Trinity River.

river otter (Lutra canadensis): although no conclusive signs of river otters were found during this inventory, it was reported as occurring on the lower Trinity River in Liberty County by two residents who were interviewed, and Davis (1966) says that it still occurs locally in East Texas. A specimen from the Attoyac River in Nacogdoches County was brought to this investigator in 1970. This semi-aquatic carnivorous mammal must therefore be considered a rare inhabitant of at least the lower part of the river.

red wolf (Canis niger): the red wolf formerly ranged widely over East and Central Texas, as far north as the Red River (Davis, 1966), but recent specimens from Texas are all from the upper coastal region, centering in Chambers County. It is difficult to gather reliable information because this species is often confused with the coyote, with which it apparently readily interbreeds. Hybrid animals add to the problem of identification (see McCarley 1959). It is this investigators opinion that red wolves could and probably do occasionally wander northward along the lower part of the Trinity River in Liberty,County, but conclusive evidence is presently lacking. This species prefers open areas with adequate cover rather than extensive forests.

cougar or mountain lion (Felis concolor): cougars are known to occur with certainty in Texas today only in the more remote parts of South and West Texas, where their numbers are apparently dwindling. This species once occurred throughout the state, and there are still frequent unconfirmed reports from many parts of East Texas. Several persons who were interviewed in Liberty County and one in Anderson County insisted that they had seen mountain lions or their tracks recently. However, in the absence of any convincing evidence it is considered highly

improbable that this species inhabits any area along the Trinity River today. Nevertheless, there are some habitats, such as the Tanner Bayou area, which could conceiveably support a pair of these animals. According to Baker (1956) the last reliable report from East Texas was from Angelina County in 1927.

wood ibis (Mycteria americana): the present breeding range of this speices in the United States is apparently restricted at least on a regular basis, to Florida (A.O.U., 1957). However, wood ibises wander widely in mid- and late summer, reaching coastal Texas by June and then continuing inland in many localities (Peterson, 1960; Wolfe, 1956). This investigator has found them to be of regular occurrence, in small numbers or groups of up to 20 individuals all along the Trinity River, first appearing in mid-June. Birds forage around the edges of marshes, swamps and lakes, but apparently only very rarely on the shore of the river itself.

roseate spoonbill (Ajaia ajaja): spoonbills nest very locally along the central and upper coast of Texas, including Chambers County, and at scattered locations elsewhere around the Gulf to Florida. It is possible that a few pairs nest in the Old River heronry (on the Trinity River just above the Liberty-Chambers county line, see Table 33). After the breeding season some individuals wander inland, and can be expected almost anywhere along the river, as far northward as Dallas. This investigator recorded a single individual along the river in northwestern Henderson County on June 27.

Mississippi kite (Ictinia misisippiensis): although this species is a locally common breeding bird in parts of the Texas Panhandle and North-central Texas, it was not known to occur as a summer resident anywhere in East Texas prior to the present investigation. A total of 13 individuals (7 adults, 5 sub-adults, and 1 bird of undetermined age) were recorded at 8 different sites along the lower Trinity River, all in Liberty County except for one site between Polk and San Jacinto Counties (approximately 2 miles below Lake Livingston dam, where 2 adults and 1 sub-adult were seen). Although sub-adults (i.e., about 1 year old) may not have been breeding, it is probable that adults were, but no nests were found. Mississippi kites prefer open wooded areas or scattered trees near water. They are known to breed locally from the southeastern part of the Great Plains across the southern part of the United States to the Atlantic coast.

osprey (Pandion haliaetus): this species is extremely widespread, breeding throughout much of North America and

elsewhere in both the Old and New Worlds. However, it is nowhere common, and North American populations have declined sharply in the past 20 years. Wolfe (1956) states that no definite nesting records are known for Texas, although he cites a report by Simmons in 1925 which claimed the species was a permanent resident along the coast. It is suspected that most summer records of ospreys from Texas are of non-breeding birds, which is likely true of the two individuals observed during this study on the lower Trinity River in June. The species is known from the state promarily as a migrant and winter resident, occurring along the coast and on the larger lakes and rivers. The osprey is a fish-eating species, and it is thought that its recent decline is a result largely of chlorinated hydrocarbons (primarily DDT) in its body tissues.

red-cockaded woodpecker (Dendrocopus borealis): because of its dependence on mature pine stands (see Lay and Russell, 1970), this is a very local species in East Texas, and elsewhere throughout its range across the southeastern United States. Rarely are suitable habitats found very near the Trinity River, and the only population of which this investigator is aware in the general area of the present inventory is one on the north side of Lake Livingston in the Brushy Creek area of Trinity County (Dan Lay, pers. comm.).

ivory-billed woodpecker (Campephilus principalis): although Wolfe (1956) considered this species extinct in Texas, there have been numerous unconfirmed sightings in the Big Thicket area of East Texas during the last ten years (unpublished report by Fred Collins, Texas A&M University), the most publicized being those of John Dennis (Dennis, 1967). Owing to the lack of evidence, many orthinologists have been unwilling to accept any of the recent reports as authentic, and some such as Dr. Keith Arnold of Texas A&M University (pers. comm.) and Dr. J. T. Tanner at the University of Tennessee (Moser, 1972) are convinced the species does not inhabit any site in Texas today. The ivory-billed woodpecker, if not already extinct, must certainly be considered on the verge of extinction, not only in Texas but everywhere throughout its former range in the southeastern United States and Cuba (see Tanner, 1942; Dennis, 1948).

In the present investigation a large woodpecker was seen and sketched by Lin Risner on July 12 as it flew along the west bank of the river about 2 miles below Highway 162 in the Tanner Bayou area of Liberty County. There is no doubt that the sketch drawn is that of an ivory-billed woodpecker, the upper wing pattern being unmistakable. If it is to be argued that Mr. Risner

did not see an ivory-billed woodpecker, then it would have to be concluded that either: (1) he sketched something he did not see at all, or (2) his sketch is not an accurate representation of what he saw. My personal knowledge of Mr. Risner's character and integrity, and of his keen ability as a field observer, leads me to conclude that he did, in fact, see an ivory-billed woodpecker. The area is a relatively undisturbed bottomland forest of some 13,000 acres.

Species of Economic Importance

Game animals

The white-tailed deer is an extremely popular and important game species along most of the Trinity River, where it reaches its largest population densities in bottomland hardwood forests (see Collins, 1961; Lay, 1965; Segelquist and Green, 1968; Stransky and Halls, 1962). Many landowners lease their property for deer hunting in the fall and there are several large hunting clubs, such as the Arizona Creek Wildlife Club in Liberty County with approximately 100,000 acres and about 2,000 members (M. J. Cain, pers. comm.). Sportsmen interviewed often said that deer hunting along the middle regions of the river was among the best anywhere in the state, and this was also the opinion of Mr. Walt Daniel, the resident game biologist in Fairfield (pers. comm.). Other mammals which are extensively hunted for sport are the gray and fox squirrels, and to a lesser extent the swamp and cottontail rabbits. Raccoon and fox hunting are also very popular sports along the Trinity River. These animals, mostly inhabitants of forested areas, provide many hours of recreation and bring a considerable amount of revenue into the region.

The Trinity watershed is one of the most valuable areas in East Texas for breeding wood ducks. Although these birds were not very often seen on the river itself, they nest in moderate densities on the wooded swamps, sloughs, and oxbow lakes on the floodplain. Sixty-four wood ducks were counted flying over the river at dusk on July 13 from an observation point near Moss Bluff in Liberty County, and on July 12 at Gaylor Lake in the Tanner Bayou area of Liberty County a total of 31 birds were counted in the hour before dark. Several broods of half-grown young wood ducks were seen on the upper and middle sections of the river in early July, always accompanied by one or both parents.

Although no data were gathered during this investigation during the winter months, this investigator was informed by numerous residents, and by Walt Daniel

of Fairfield, that the same areas utilized for breeding by wood ducks are frequented by many hundreds of wintering waterfowl from October through March. These birds are extensively hunted and their popularity among hunters ranks with that of the white-tailed deer. The site of the Old River heronry (Table) is a 1,700 acre duck hunting preserve. This very large swamp is located about one mile west of the river and two miles north of the Liberty-Chambers county line.

Fur-bearing animals

Beavers are more abundant in the Trinity River watershed (to the knowledge of this investigator) than they are anywhere else in the state of Texas. Dan Lay (pers. comm.) stated that populations along the Trinity River were introduced there from West Texas populations in the late 1930's and early 1940's after native beavers had been virtually exterminated from East Texas in the early part of the century. Owing to protection given them by law this species made a remarkable comeback along the Trinity River, to the point where they are now sometimes considered a nuisance and a pest. Although they have valuable pelts, and trapping permits can be obtained from the Texas Parks and Wildlife Department, there appears to be little interest in commercial trapping of beavers along the river today. Likewise, there is an apparent lack of interest in exploiting the mink, another relatively common fur-bearing mammal inhabiting the Trinity River.

A third species, the introduced nutria from South America, also has a pelt of potential commercial value, but this investigator is not aware of any nutrias being trapped for their fur. Although not common on the river itself, the nutria was rather frequently encountered in marshes or lakes near the river, and on some of the larger slow-moving tributary streams such as Redmond Creek in lower Liberty County. At times nutria populations can build up in a marsh, lake, canal, or irrigation ditch to the point where the animals become a major pest by eating all of the aquatic vegetation, or even crops and pine seedlings (Evans, 1970; Atwood, 1950).

Sites of Particular Ecological Importance

From an ecological viewpoint there are many valuable areas along the Trinity River. The most extensive remaining forest areas have been outlined by Dr. E. S. Nixon in the botanical section of this overall report. All of these sites are very important for wildlife.

These include: (1) the forest area between the old and new channels of the East Fork of the Trinity River in Kaufman County, at their confluence with the Trinity River; (2) the Bruce Smith Ranch on the east side of the river in Henderson County, southwest of Tool (in the Sanders Creek general area); (3) the east side of the river in Anderson County in the general vicinity of Big Lake, several miles above Highway 84 crossing; (4) the south side of the river in Walker County in the Black Creek/White Oak Creek area; (5) the north side of the river in Walker County on the Earl Moore Ranch in the Horseshoe Lake area; (6) the south and west side of the river in San Jacinto County south of FM 1127 in the Davison Bayou/Coley Creek area; (7) most of the west side of the river in Liberty County between the New River Lakes Development and Sam Houston Lakes Development (approximately the middle region of the river between Highways 105 and 162); (8) the Tanner Bayou area on the west side of the river in Liberty County between Highway 162 and Capers Ridge; and (9) a large forested and swampy area on the west side of the river in Liberty County across from Moss Bluff, generally from about 1-1/2 miles north of the county line north to the Harrison and Timber Lake subdivisions.

Although the above sites are considered to be the best wildlife areas along the river at the present time, it should be emphasized that numerous other sites are also highly valuable, including all nesting colonies of herons and egrets (see Table 33). In Liberty County where most of the river is extensively forested on both sides it is difficult to single out specific sites as being more important than others. However, the present survey of the river indicates that the Tanner Bayou area is almost certainly the most significant and valuable ecological area situated anywhere along the Trinity River today. Every effort should be made to preserve it. Currently, most of the approximately 13,000 acres of forest in this area is owned by the Kirby Lumber Company, and the area is leased for both hunting and grazing. However, because of the inaccessibility by road to much of the area, it remains relatively little disturbed by man. It is possible that one or more ivory-billed woodpeckers may inhabit this area.

CONCLUSIONS

The Trinity River lies on the western edge of the Austroriparian biotic province (Dice, 1943; Blair, 1950), and its avian and mammalian faunas are, in general, typical of those of the whole southeastern United States.

Its position places the river in an important ecological region where eastern forest species come in contact with species characteristic of the grasslands of the Great Plains. The Trinity River is thus in a transition zone where many forest birds and mammals reach the western limit of their range and some prairie species reach the eastern extension of their distribution. This mixing of fauna is most evident on the upper part of the river. Usually the plains species inhabit upland situations and eastern species lowland habitats. Forest birds such as the Swainson's and hooded warblers were not found farther up the river than Anderson County, and species such as the field sparrow and western kingbird were not encountered farther south than Freestone and Navarro counties respectively.

There is an abundance and varied bird and mammal fauna inhabiting the Trinity River Watershed. The diversity is greatest in the bottomland and floodplain forests adjacent to the river, and these habitats are of considerable importance in the overall ecosystem of the river as are the many swamps, sloughs, and oxbow lakes lying back from the river along most of its length. These areas provide breeding and foraging sites for many important game animals, and several very large nesting colonies of herons and egrets are situated within a few miles of the river. The river itself is utilized extensively for foraging by many species of large wading birds, and also by anhingas, wood ducks, kingfishers, small shore birds, and an occasional osprey, the latter one of the endangered North American birds. Mississippi kites apparently breed along the lower river and nowhere else in East Texas.

Beavers may be more numerous on the Trinity River than anywhere else in the state, and some of the finest deer hunting in Texas is available in some of the forested areas along the river. The trees and woodlands along the river are available to many kinds of small songbirds during spring and fall migrations, and waterfowl which nest in northern North America can utilize the numerous swamps and lakes on the floodplain during the non-breeding season. The Tanner Bayou area may be one of the few remaining sites anywhere in the United States where the ivory-billed woodpecker still persists.

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CHAPTER VII

FOREST HYDROLOGY AND CONCEPTUAL LAND USE CAPABILITIES

by

J. Robert Singer
and
James W. Martin

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INTRODUCTION

The relative impact of channelization and construction of Tennessee Colony Reservoir were to be considered. This is essentially a planning problem to obtain interrelationships and relative values. The matrix approach allows an investigator to systematically approach the actual problem of development planning (environmental impact from a proposed developement) when time and information are limited. This report presents methodology for both the channel study and the reservoir study. The channel study is at the reconnaissance level; findings are presented herein. The Tennessee Colony study was in-depth; details are presented in a previous report.

A matrix approach allows use of available data and does not foreclose chances to use additional data as it becomes available. The impact functions matrices for both the reservoir and the channel are based on the standard "if-if-then" format of an objective scientific hypothesis.

Each impact is a potentially measurable and quantifiable magnitude. The impact magnitudes are relative. They are relative measure of sensitivity of a part of the environment to the proposed action. Therefore, this study has identified the types of problem areas in which reasonable quantitative estimates may be needed at time of decision-making.

Land management decisions in this study are viewed within the context of land use capacity based upon the comparison of projected soil and forest hydrology conditions for watershed and land uses. This is done to determine the relative impact that may be caused by the proposed channel upon existing soil and forest hydrology in the Trinity River Basin.

Each environmental factor requires overall consideration of all influencing factors in order to determine the impact of the channel. Based upon ecological considerations of land surrounding the proposed channel a determination and definition of broad capability categories of land for residential, recreational,wildlife, or agricultural development and use was made. In addition, a study of existing forest hydrological and soil conditions influencing watershed management was made.

A concept plan of land use was made with alternatives listed from the most to the least desirable use based on soil limitations established by the Soil Conservation Service. The relative impact of the proposed channel upon the present forest hydrological conditions was also made. Using a portion of each of thirteen randomly selected watersheds as examples (Table 36), this study provides the basis for comprehensive in-depth studies of problem areas identified herein.

The Trinity River Basin channel project from Fort Worth-Dallas to just east of Houston will create a channel of approximately 342 miles in place of the existing 553 mile river. The geographical extent of this hydrological and land use study is presented in Figure 36 .

Purpose

The primary purpose of this study was to conduct a reconnaissance level environmental inventory of land capabilities within the river basin. Of equal importance was the determination, interpretation, and evaluation of the environmental impact that may be caused by the construction of the channel upon existing forest hydrology, present watershed management conditions, soils, and land uses. Alternative land uses to mitigate the impact are to be stated along with areas where it is felt that in-depth investigations need to be conducted.

Objectives

The objectives of this study were:

1. To conduct a reconnaissance level environmental inventory of forest hydrological, soil, and watershed conditions and to determine the relative impact of the project upon these.

2. To conduct an inventory at the reconnaissance level of natural and cultural environmental strata relevant to conceptual land use planning.

3. To identify zones of relative impact caused by the channel and describe present land uses.

TRINITY RIVER BASIN
LOCATION MAP

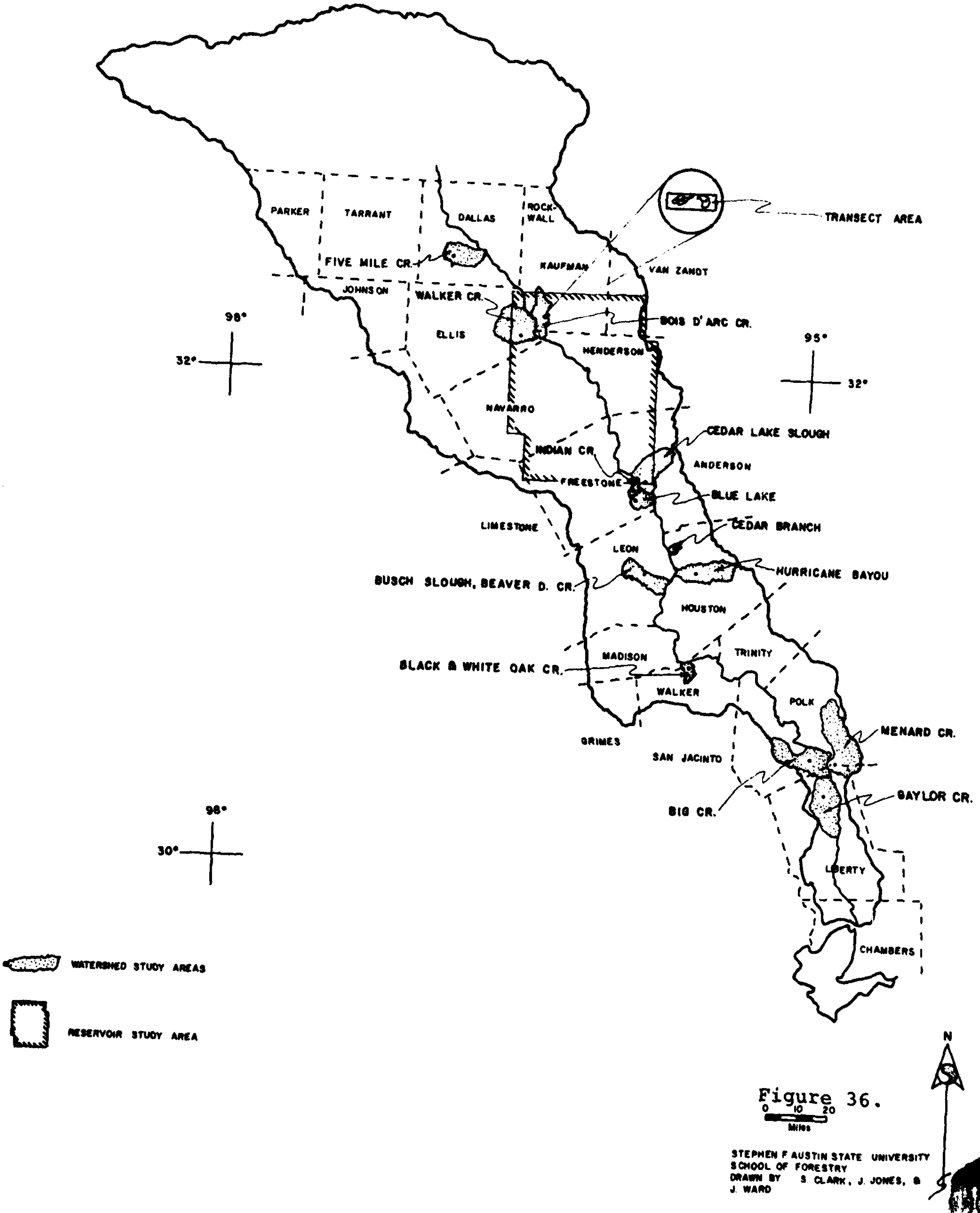

Figure 36.

Table 36. Thirteen selected watersheds used in the Trinity River Basin study.

Watershed Name	Watershed Type	Quadrangle Sheets*
Upper Section (Fort Worth-Dallas to Tennessee Colony)		
Five Mile Creek	Perennial	751,752,752, 753,754,802, 803,804
Walker Creek	Intermittent	055,056,057, 105,106,107
Bois d'Arc Creek	Perennial and Intermittent	008,009,058, 059,108
Middle Section (Tennessee Colony to Lake Livingston)		
Indian Creek	Perennial	413,463
Blue Lake	Intermittent	464
Cedar Lake Slough	Perennial	364,365,366, 414,415,464, 465
Cedar Branch	Intermittent	616
Hurricane Bayou	Perennial	619,620,667, 668,669,670, 717,718,719
Busch Slough and Beaver Dam Marsh	Perennial and Intermittent	663,664,665, 666,714,715, 716
Black and White Oak Creek	Intermittent	067,068
Lower Section (Lake Livingston to Wallisville)		
Big Creek	Intermittent	223,273,274, 276,323,324, 325,326

Table 36. Continued

Watershed Name	Watershed Type	Quadrangle Sheets[*]
Menard Creek	Perennial	126,127,176, 177,226,227, 228,276,277, 278,279,327, 328
Gaylor Creek	Intermittent	325,326,375, 376,377,425, 426,427,476, 477

[*] Sheet numbers correspond to the coordinate numbering system used by the Texas Forest Service for fire control.

4. To identify areas of uniqueness in the natural environment that are limiting factors for land use adjustments.

5. To develop complementary maps showing the location of various limiting factors.

Scope

The specific environmental strata to be identified and inventoried for this study are:

1. Vegetative condition of the land
2. Slope characteristics
3. Soils
4. Hydrological character of the soil
5. Soil capability limitations
6. Outcroppings of major and minor aquifers

These data are to be interpreted from a land capability perspective and viewed in terms of impact zones based upon forest hydrology, soils, and watershed conditions for selecting alternative land uses. Land capability as used in this study is an expression of the type and intensity of use a specific land area can support without environmental degradation.

Methodology

The land use concept and hydrology plan is based on land capability. To establish this capability certain limiting factors must be identified and their extent expressed. Among these factors are major and minor aquifers, surface water-soil relationships, slope, vegetation, soils, and distance from the channel and proposed reservoir.

Base maps used were 7-1/2 and 15 minute U. S. Geological Survey topographic maps. Each base map was subdivided into 5 minute blocks to conform with the Texas Forest Service fire control map numbering system. This allowed convenience in filing and handling plus immediate area identification.

In the channel part of the study, the boundary of each watershed was delineated on the topographic maps. Soils information was obtained from county Soils maps supplied by the Soil Conservation Service, U. S. Department of Agriculture. Drainage capabilities of each soil series was the primary criterion used in determining possible impact zones.

Slope of each watershed area was divided into one of three categories of position and degree (Figure 37).

Lower position: from the stream bed to the first major topography break in the slope.
Middle position: from the first major topography break to the second major break.
Upper position: from the second major break to the top of the slope and/or the watershed boundary.

The percentage of slope within each slope position was divided into three categories: (1) less than 2 percent, (2) 2 to 10 percent, and (3) 10 percent and greater. These slope positions and degrees were used in determining erosion and drainage sensitive areas within each watershed.

These areas were determined by the Impact Functions Matrix (Table 37) for watershed areas. The Matrix involved six relative degrees of impact. For example: if the soil drainage characteristics are excessive and if the percent slope is over two but less than ten then the relative impact of increased drainage will be a minus six. The matrix is further discussed in the section on impact areas.

Minus Nine Areas: may exhibit excessive change in water fluctuation over 10 plus years than are now experienced in the area. These sites would convert to droughty conditions that would persist most of the year.
Minus Six Areas: may exhibit moderate change in water fluctuation over 10 plus years than are now experienced in the area. These sites would convert to drier conditions than previous conditions during the driest part of the year and would remain dry for upwards to six months.
Minus Three Areas: may exhibit little change in water fluctuation over 10 plus years than are now experienced in the area. These sites would remain much as they now are during the entire year, fluctuating with the annual precipitation-soil type combination.
Plus Nine Areas: may exhibit excessive change in water fluctutation over a five year period than now are present in the area. These sites would convert to drier conditions due to drainage of wet areas that persist most of the year.
Plus Six Areas: may exhibit moderate change in water fluctuation over a five year period than are now experienced in the area. These sites

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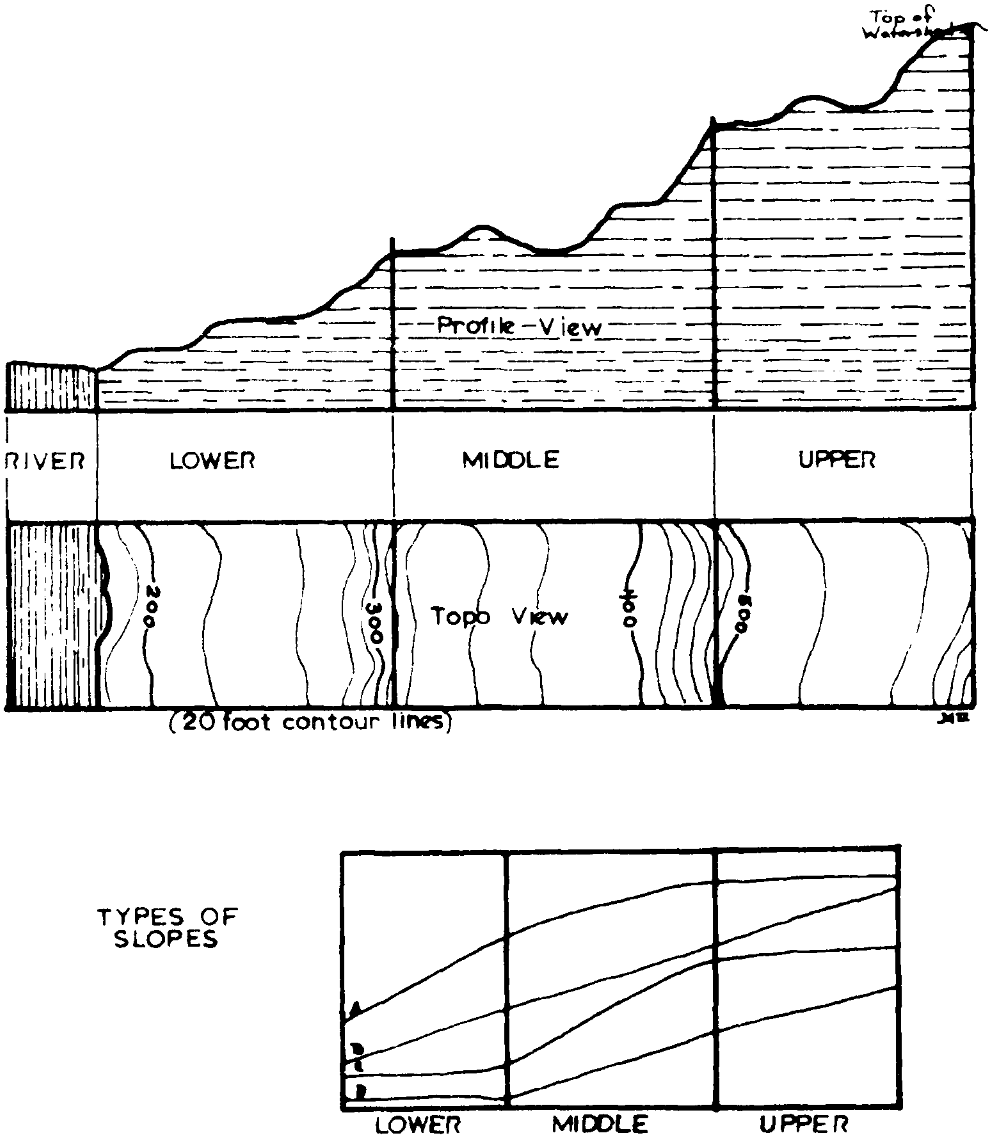


Figure 37. Watershed Slope Positions

Table 37. Impact Functions Matrix, Channel

Drainage Characteristics	Percent Slope	Slope Position		
		Upper	Middle	Lower
Excessive	10 plus	-9	-6	-3
	2-10	-6	-3	0
	0-2	-3	0	0
Well	10 plus	-6	-3	0
	2-10	-3	0	0
	0-2	0	0	0
Well to Moderate	10 plus	-3	0	0
	2-10	0	0	0
	0-2	0	0	0
Poor to Imperfect	10 plus	+3	0	0
	2-10	0	0	0
	0-2	0	0	0
Poorly	10 plus	+6	+3	0
	2-10	+3	0	0
	0-2	0	0	0
Very Poorly	10 plus	+9	+6	+3
	2-10	+6	+3	0
	0-2	+3	0	0

Indicates Zero Impact

Note: Matrix numbers represent degree of relative impact. Each is a potentially measurable and quantifiable magnitude.

which are normally wet for upwards to six months of the year would become drier during the wettest part of the year.

Plus Three Areas: may exhibit little change in water fluctuation over a five year period. These sites which are normally wet all year would remain much as they are with added drainage improving them during the drier portions of the year.

The minus and plus nine areas would be of greater importance in terms of environmental change than any of the other ratings.

A technique for identifying environmentally sensitive areas (Singer and Miller, 1972) was applied to the topographic maps of each watershed. The grid divided each area into rectangular plots containing 92.72 acres; each plot is approximately 1847 by 2187 feet. These plots were all identified by letters, thus allowing for convenient identification and location of information as well as a computer adaptable system for information storage and recall. This system was also utilized to identify ground cover within each watershed. Ground cover was classified as either forest, field-forest, or field according to color designation on U. S. Geological Survey topographic maps which were aerial photo corrected to 1968. Aerial photographs and field checking were used to identify the area and type of forest cover.

Geological data were obtained from the Bureau of Economic Geology, University of Texas. This information was arranged within the report in the same manner as were the topographic data. Aquifer groups, major and minor, were determined by grouping specific aquifer members. Their locations were plotted on the base maps. Watershed study transects were located with respect to the underlying geological information.

Transects in each watershed studied were selected to show representative areas of typical impact diversity. (Table 38). Each transect line was designated to illustrate areas of impact and nonaffected areas. After location, these areas were field checked and the information transferred to figures showing impact delineation, topographic relief, aquifer association, vegetative associations, and soil series.

The Soil Conservation Service soil use interpretations (U.S.D.A., S.C.S., 1969) served as a base for land use projections. Hydrologic capabilities of the various soils served to establish priority projections of alternate land uses.

Table 38. Sample Impact Transects*

Watershed Name	Transect location Quad sheet number
Upper Section (Fort Worth-Dallas to Tennessee Colony)	
Five Mile Creek	752
Walker Creek	106
Bois d'Arc Creek	008
Middle Section (Tennessee Colony to Lake Livingston)	
Indian Creek	463
Blue Lake	464
Cedar Lake Slough	465
Cedar Branch	616
Hurricane Bayou	668
Busch Slough & Beaver Dam	665
Black & White Oak Creeks	067
Lower Section (Lake Livingston to Wallisville)	
Big Creek	274
Menard Creek	277
Gaylor Creek	376

*For transects, see Figures 40 through 52 in the summary section.

Present land use within the study areas was studied to permit an identification of problem areas. They should be studied in greater detail to determine effects of the channelization and reservoir construction projects. However, at the present level of study, limiting factors influencing land use changes within the immediate channel and reservoir area were only identified.

The methodology used for the in-depth study in reservoir vicinity was similar. The first step in locating possible impact zones was to identify all areas of topography of 2-1/2 percent slope or less that would be in contact with the reservoir. This is the land area where the water in the reservoir would most influence the water in the soil profile. Soil drainage classes from Soil Conservation Service sources were now utilized. These ranged from excessive to very poor. These two criteria were used to determine, on topographic sheets, the extent of the zones in which soil moisture changes could be expected. A line of zero impact was developed based on elevation above pool level and soil characteristics.

A control was used. Two existing reservoirs in the area were analyzed in the same manner. They were then field checked to obtain a description of the nine, six, and three magnitudes in the matrix. A description of the magnitudes follows:

1) Minus nine areas exhibited excessive change in soil moistures as evidenced by vegetation.
2) Minus six areas exhibited moderate change in soil moisure.
3) Minus three areas exhibited some change.

This approach was then applied to the boundary of the proposed reservoir. Zones were given magnitude ratings depending on elevation from the expected pool level.

Field inspection of present land uses was used as the final modifier of impact magnitude. For example, forested areas in a three magnitude retained a three rating. Agriculture fields in a six magnitude were assigned a nine rating. Land use change to a lower intensity use may decrease the nine to a six or even a three.

It is believed that designated impacts are the maximum that could occur. They are not the impacts that will occur. Land use adjustments will be the final modifier. The matrix used around the reservoir is

shown in Table 38a . In the interest of brevity, the reader is referred to the interim report for more detail as well as for maps.

WATERSHED MANAGEMENT CONSIDERATIONS

The construction of the proposed channel will create zones of impact affecting watershed management conditions within the study area. The degree of this affect will be dependent upon the magnitude of the impact zone, as well as present and potential land use for each affected area.

Vegetation Management and Manipulation

The vegetation change will be of interest to foresters, ranchers, farmers, and local residents depending upon land use. In the following explanation of the various impact zones it should be pointed out that this is a generalized approach for land use based upon the reconnaissance level. It is recognized that the upper, middle, and lower sections of the Trinity River are individualistic in nature.

Minus Nine Zone: areas of greatest impact in which vegetation may become upland forest or plant associations. Increased droughty conditions may result in plant mortality due to increased watershed drainage.

Minus Six Zone: areas of medium impact in which plant associations may not change, but increased tree mortality might result from a combination of increased drainage and prolonged seasonal droughty conditions.

Minus Three Zone: areas of minor impact where only a severe droughty condition of a prolonged nature will result in mortality of trees. Seasonal increased droughty conditions will produce a decline in forest vigor, thus reducing the value of forest cover.

Plus Nine Zone: areas of greatest impact in which land now stagnant or swampy with only none commercial plant species will change to commercial species due to increased watershed drainage by the channel.

Plus Six Zone: areas of medium impact in which plant associations will change only slightly. Tree species with high water requirements and shallow rooting habits will be replaced by those with deeper rooting habits and less water requirements as a result of increased drainage and prolonged seasonal droughty conditions.

Table 38 a. Impact Functions Matrix, Impoundment

	Elevation above Impoundment in Feet				
Drainage Characteristic	+10	+20	+30	+40	+50
1. Excessive	-9	-6	-3	0	0
2. Well	-6	-3	0	0	0
3. Moderately well	-3	-3	0	0	0
4. Imperfect	-6	-6	-3	-3	0
5. Poor	-9	-6	-3	-3	0
6. Very poor	-9	-9	-6	-3	0

Indicator of zero impact line on map

Note: Matrix numbers represent degree of relative impact.

Plus Three Zone: areas of minor impact where only a severe droughty condition of a prolonged nature will result in mortality of trees. Seasonal increased droughty conditions will produce an increase in forest vigor of less water demanding species, thus increasing the value of forest cover.

Aquifer Formations

An aquifer is defined as a geological formation, a group of formations, or a part of a formation which is water-bearing. The name is usually restricted to those water-bearing areas capable of yielding water in sufficient quantity to constitute a useable supply for a rural system. Because of their varying ability for supplying water, aquifers of the state have been classified as either major or minor water-bearing formations.

Major Aquifers: major water-bearing formations yielding large quantities of water over large areas of the state. Three of these occur in the Trinity River Basin (Carrizo-Wilcox Sands, Trinity Sands, and the Gulf Coast Group).
Minor Aquifers: minor water-bearing formations yielding large quantities of water in small areas of relatively small quantities over large areas of the state. Two of these occur in the Trinity River Basin (Sparta Sands and Queen City Sands).

In as much as these aquifers are recharged mainly by precipitation and stream overflow, the effects of channelization should be minimal. Vegetation and land uses on the aquifer recharge site are of major consideration. Various types of land uses such as residential areas, highways, or any other use which reduces infiltration and speeds up surface runoff will reduce the amount of water entering these aquifers. Some of the land uses may also increase the amount of pollutants entering these underground water sources.

REGIONAL LAND USE

Existing land uses in the Trinity River Basin are greatly diversified. Each section of the basin has its predominant land use. In the northern section from Fort Worth and Dallas to the Tennessee Colony Reservoir are found population centers, industry, agricultural lands, and major transportation systems.

In the middle section from Tennessee Colony to Lake Livingston, agriculture is the predominant land use. Here agricultural land is used for either row crops and for orchards or livestock raising. The lower portion of the river basin from Lake Livingston south to Wallisville is predominantly used for forestry. In this region there is an increasing use of land for pasture and for home development.

Agriculture

Row crops are mostly limited to the west side of the river in Navarro and Ellis counties due to soils and rainfall. Cotton is the major crop followed by feed crops, and pecan and peach orchards. It appears that there will be little change in this form of land use due to channelization.

Throughout the basin there are small truck farms, grain fields, and orchards. The channel should have very little effect on these areas.

Pastures are found throughout the entire basin, but are more predominant in the middle and lower portions of the river. The greatest areas of improved pasture land is found in the first bottoms where the soils stay moist and flooding is not a serious problem. These areas may experience the greatest impact if the surface and subsurface moisture pattern is changed by the channelization project.

Upland pastures are mostly small with approximately one-half of them being unimproved. These areas will be affected only if they have a rating as either a minus nine or minus six and the predictions of drier conditions result.

An increasing amount of land is being converted in the lower and middle sections of the river to large improved pastures. The major problem besides soil moisture with pastures may result from the channel cutting through these areas and creating an access problem for landowners.

Forestry

Timber production is the predominant land use in the lower part of the basin from Lake Livingston to Wallisville. The forest cover is pine and pine hardwood in the upper areas of the watersheds. Second growth hardwoods occupy the areas near the river. Since much of this area

is presently being converted to residential and agricultural uses, the effects of the channel should be minimal. This prediction is further emphasized by the fact that the hardwood timber along the river has been cut over several times and present timber is of poor quality.

Recreation within the river basin is mostly in the form of hunting and fishing. There is some limited development of camping and picnicking, but there is good development potentials in this area. Many of the created oxbow lakes may have good recreation and wildlife potentials. Further, their existence can provide the basis for encouraging commercial developments such as marinas.

Population Centers

Dallas, Fort Worth, and a portion of the Houston area form the metropolitan areas for tha basin. The other cities in the basin averaging over 7,000 inhabitants are Palestine, Crockett, and Livingston. There are numerous smaller cities of 2,000 or less inhabitants scattered throughout the basin. In the area below Lake Livingston to Liberty there are several land development companies at work creating new communities, but these are almost entirely vacation homes.

Industry

The major acreage of commercial lands are centered in Dallas, Fort Worth, and Houston. The other centers with any type of industry, with the exception of Crockett, are located away from the river. The Texas Power and Light Company, with generating facilities at Trinidad and Fairfield, constitutes the major industry on the river between the two metropolitan areas. There are some timber industries located in the lower part of the basin, but none of them are presently located on the river.

At Liberty there are some plants using the river for barge traffic now. The advantages of cheaper shipping will probably move more industry towards the river, especially in the Fort Worth-Dallas area and at Crockett and Liberty.

Transportation

Highway routes, both primary and secondary, are located throughout the basin, providing an efficient system in the upper and middle sections of the river.

Primary highways and especially river crossings are lacking in the lower part of the basin.

Railroad routes follow the same patterns as highways, but are more closely tied to the larger population centers. As the basin develops in terms of residents, recreation, and industry, the amount and quality of transportational facilities within the region will probably increase. The construction of vacation homes has already begun this development in the area below Lake Livingston.

FACTORS INFLUENCING LAND USE CHANGES

With the channelization of the river a new environment will be created within the basin. The factors with the most influence on land use changes will include soils, created oxbow lakes, geology, groundwater recharge zones, water production areas, and population centers.

There will be little change in the upper portions of the watersheds. In those portions of the watersheds under the direct influence of the channel there will be some change. In the portions of the river near Fort Worth and Dallas, around Lake Livingston, and from Lake Livingston Dam to Liberty, there will be much change from present land uses within 10 years of the project's completion.

The authors believe that the portion of the river nearest Houston will experience the greatest development. It will be composed of industry as well as residential and vacation homes. Within the entire basin there are those areas which will only tolerate low use intensity and still maintain their value. These areas serve as key indicators to the degree of use intensity which the land is capable of maintaining without degradation. As pressure mounts for increasing the intensity of land use, consideration must be given to areas that can tolerate only low intensity use.

Impact Areas

The channel will affect these zones through soil moisture fluctuation and groundwater influence. The effects will be either a permanent decrease in soil moisture and water table level or fluctuating soil moisture and water table. The primary criterion for an impact zone is the slope of the land. A second set of criteria based upon the interrelationships of elevation above the channel and the soil drainage characteristic

is added to the first to determine the true influence of slope.

Based upon the interrelationships between soil drainage and elevation above the channel, a matrix of relative impact was developed (Table 38). Initially, when elevation increases, impact also increases due to the natural pull on present soil moisture by gravity. The rest of the matrix deals with soil drainage and its influence upon the speed of this decrease in soil moisture. The influence of this increased drainage may be negative or positive depending upon the initial conditions of the soil-water relationship.

The final decision in positioning of the iso-impact line lay with the on-site land use modifier. This modifier was expressed in terms of the relation of the vegetative cover and soil moisture regime, present and anticipated.

After each study area on the thirteen designated watersheds were analyzed and assigned a pre-inspection value (minus 9,6,3 or plus 9,6,3), iso-impact lines of minus 9,6,3 or plus 9,6,3 were drawn on the quadrangle sheet. Areas with a zero rating were left blank. The values were relative in that a minus 9 is not catastrophic, but is a great deal more sensitive than a minus 3.

The field inspection proved to be the real modifier in the system of determining the true impact of an area. It was found that the original Impact Functions Matrix (Table 38) overestimated the degree of impact in the upper and middle sections of the river in areas outside the first bottom. The upper sections of the watersheds will not convert to droughty conditions unless a prolonged drought period exists. The vegetation in these areas is probably more dependent upon climatic factors than the river. Therefore, it was found that all ratings in these areas should be decreased one class where a minus impact rating was concerned. Plus impact areas were found to be fairly accurate in these areas and were not adjusted.

Groundwater Recharge Areas

Groundwater recharge is the ability of the land to recharge the underlying aquifer. The rate and degree of recharge depends on how fast water infiltrates the soil and reaches the geologic formation. Land use on aquifer outcroppings should maximize the recharge potentials. The limiting factor is not the aquifer outcrop, but rather the combination of the outcropping and land use.

The transects presented in the environmental impact analysis section depict areas where groundwater recharge potentials must be a major consideration in land use. Primarily this factor is concerned with any land use that increases surface runoff and soil compaction because these two phenomena decrease recharge.

Soils

The soils in each of the study areas ranged from excessively to very poorly drained. Drainage is one parameter in the Impact Functions Matrix. The following description of drainage is taken from the classification system used by the Soil Conservation Service.

> Excessively drained soils: are deep, excessively drained, and strongly acid sandy soils. An example is the Lakeland Series.
> Excessively to well-drained soils: are well drained, very slow permeability, and moderately deep upland clay. An example is the Lakeland-Bowie Series.
> Moderately well-drained soils: are areas of upland clay, very slow permeability, calcareous, and moderately well-drained. An example is the Bell-Burleson Series.
> Well to moderately well-drained soils: a deep upland soil that is well or moderately well-drained. An example is the Trinity-Catalpa Series.
> Imperfectly to somewhat poorly drained soils: is an upland soil that has a very slow permeability and is also a fine sandy loam with varying drainage due to mottling in the subsoil. An example is the Tabor Series.
> Poorly drained soils: is a bottomland soil with gentle sloping floodplains. It is somewhat poorly drained and has a very slow permeability. An example is the Navasota Series.

CONCEPTUAL LAND USE CHANGES

As the Trinity River is channelized and the land is drained at an increased rate, certain land use changes will take place. These changes will vary in number and importance due to the absence of ground and surface water in the upper part of the basin and the abundance of it in the lower portion. This change will be guided by influential environmental factors. Some of these land use changes will involve recreation, residential, wildlife and agricultural.

Oxbows

The land use projections in this phase of the study were based upon the assumption that various sized oxbows will be formed as a result of the proposed channelization. The land use within each of these oxbows will be based upon the type of stream flow that will be feeding the area: intermittent, perennial, or none.

The various types of land uses are divided into four major categories: (1) residential and recreation, (2) wildlife and wetland habitats, (3) agriculture, and (4) erosion control. These categories are related to size, topography, vegetation, present land use, soil drainage, and soil capability of the oxbow. It is recognized that there will be a limited amount of these areas on the upper part of the river because there will be little water available to sustain oxbows and the channel at the same time.

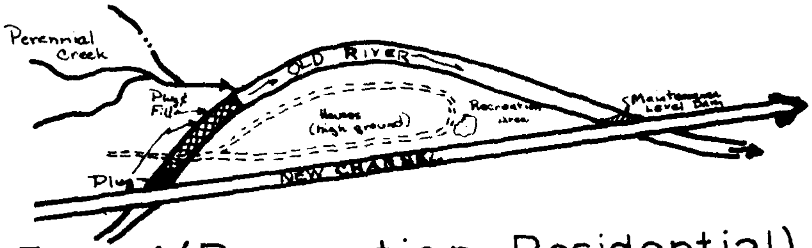
The types of oxbows fall into three categories (Figure 38).

> Type one oxbow: is formed by intermittent and/or perennial streams flowing into oxbows that will be formed and maintained at the present stream level by placing a plug dam upstream and a maintenance level dam at the downstream end to prevent any potential channel pollutants from entering.
>
> Type two oxbow: is formed by intermittent streams flowing into oxbows surrounded by low lands subject to overflow. A fluctuating water level will result from prevailing climatic conditions. A marshy low-land area can be created by placing a plug dam at the upstream end and a maintenance level dam at the downstream end.
>
> Type three oxbow: is formed by oxbows without any streams flowing into them. These will dry up, with only pot holes of water developing during wet seasons.

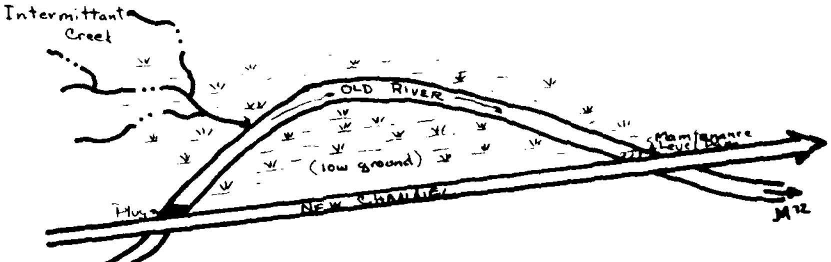
A diversionary structure, which would allow channel flow into an oxbow, would allow another series of alternatives based on local conditions. For example: a Type 3 area could be upgraded to a Type 2 or 1 and a Type 2 could be changed to a Type 1 area.

Types of Conceptual Land Uses

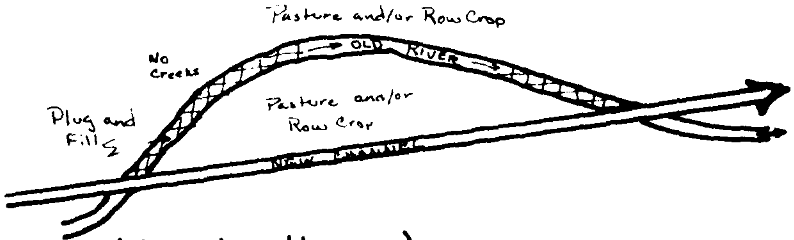
There are various types of land uses that can be projected for each of the previously mentioned oxbows:



Type 1 (Recreation-Residential)



Type 2 (Wildlife-Wetland)



Type 3 (Agriculture)

Figure 38. Types of Oxbows

Residential and recreation areas: these uses may be considered in areas designated as either type one or type two oxbows. In areas with high banks and good soil drainage there is a potential for private recreation or residential development. If these oxbows are forested, this development potential is even higher. In the upper part of the river there will be relatively few such sites. The majority of desirable sites will be found in the middle section of the river due to the higher banks, more sandy soils, and increased amounts of stream discharge into these oxbows. The most desirable development zone is the lower section because of the proximity to Houston and Beaumont. Due to the low topography of much of this section there will be a limited amount of desirable sites.

The development of the recreation potential will help benefit other forested recreational sites in the East Texas region. The extent of this type of development along with residential areas will be regulated by the size and location of the oxbow, soil capabilities, and the stability of water level in the oxbow.

The development of areas for these uses would nullify all or most of any adverse impact created in the upper portions of the watersheds due to excessive drainage. These areas would create good fishing streams and not require channel water to keep them flowing.

Wildlife and wetland habitats: areas designated as type two oxbows would lend themselves to development as wildlife and wetland habitats. As these areas have soils with poor drainage and are subject to flooding, their value for other land uses is limited. These areas would be found almost exclusively within the lower part of the river basin.

The major problem with these areas would be the limitation of acreage suitable for this use. Another problem would be the dependence upon climatic conditions for water in most of them. A major advantage would be to offset any loss of wetlands drained by the channel.

Agriculture: these areas would fit the type three oxbow the best. As stated before, the created oxbow would eventually dry up and leave an area in the landscape with little use. Provided these lands are not too distant from the new channel and the dry oxbow not too long in length, they could provide excellent areas to dispose of dredge materials. By bringing the old river channel up to

the level of the surrounding land and clearing portions of the newly created oxbow if it is vegetated with low value species, these areas would make good pasture or crop land.

An advantage of this type of development would be to create new agricultural land to help compensate for any that may have been taken for the new channel. It would also serve to dispose of dredge materials.

Erosion control: another type of land area that must be dealt with is areas where large intermittent or perennial streams are flowing directly into the channel. In cases where the new channel intercepts these streams at an upstream position from their present point of input into the river a problem area may be created. If the new point of interception produces a difference between the existing stream bed level and the new channel there may be an erosion danger for the entire watershed (Figure 39).

The stream will seek to re-establish a new base gradient and may, over a period of 10 to 20 years, cut a new stream bed at a lower level to establish this gradient unless prevented by either geological formations or the construction of a stream level maintenance dam and spillway. The latter would serve the majority of the situations in the basin due to the lack of rocky formations which would prevent the stream from cutting a new bed level.

Unless attention is given to these areas, the upper portions of the watershed could experience increased erosion problems. This could only be prevented or reduced through the use of extensive and controlled watershed management practices in the upper portions of the watershed.

Land Use Capabilities

Land use capabilities in the river basin fall into four major categories. Each of these categories is further subdivided by various soil series. Tables 39 and 40 explain use limitations and use alternatives for each soil class and series. Table 41 describes what forest tree species are most likely to be found on each of these series and what would be the best species to plant. In this last table, some of the soils have nothing listed for them due to their inability to produce any timber species of commercial value.

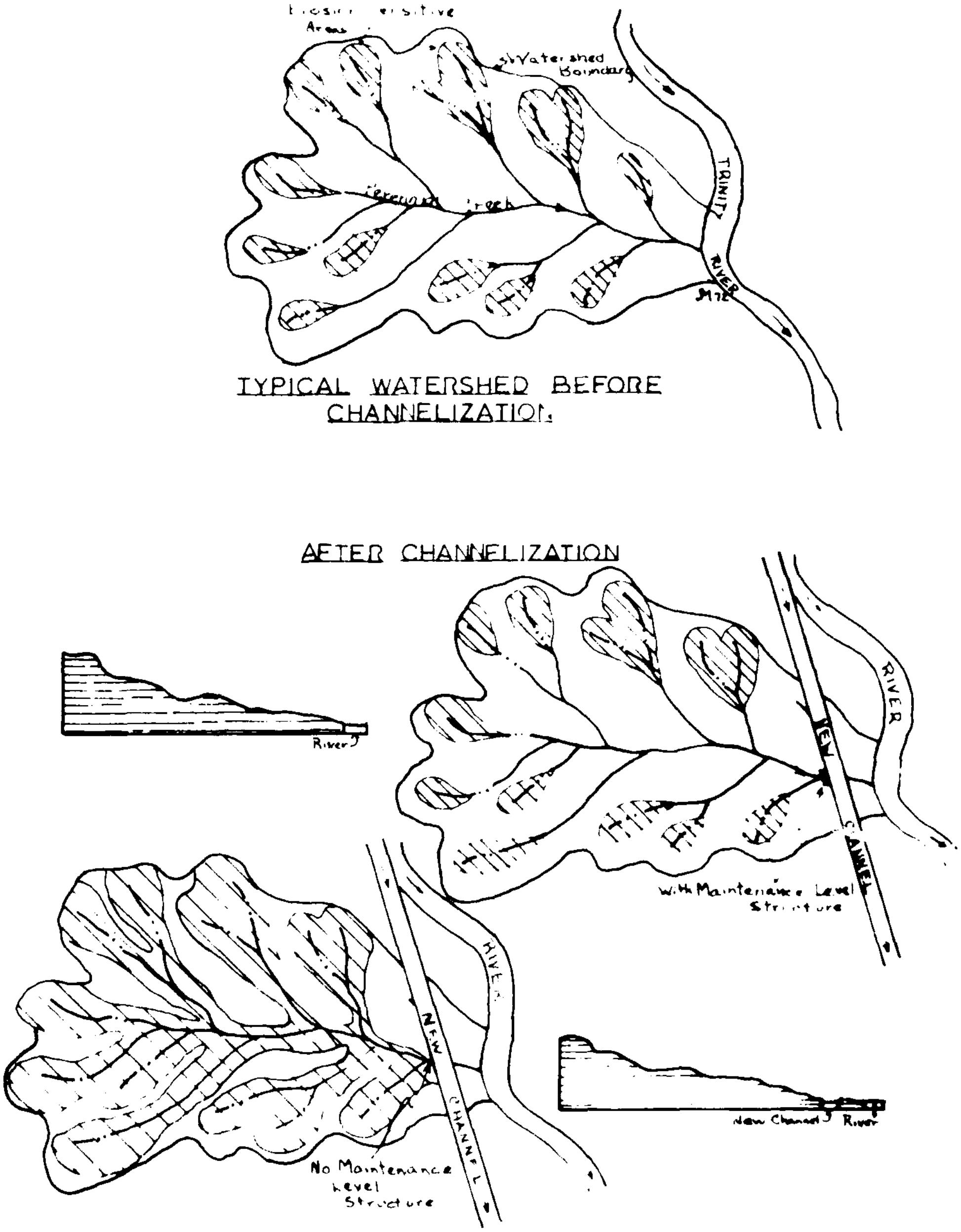


Figure 39. Erosion Control

Table 39. Use activity limitations by soil classes and series*

Soil Classes and Series	Use Categories										
	Highway Location	Small Reservoirs	Excavated ponds (runoff fed)	Corrosivity - uncoated steel	Corrosivity - concrete	Foundations for low buildings	Septic tank filters	Sewage lagoons 0 to 2% slopes	Sewage lagoons 2 to 5% slopes	Streets and low cost streets	Light industry
Class II Series											
Alto	M	M	M	H	M	M	S	SL	M	M	S
Kaufman	S	SL	SL	VH	M	S	S	SL	S	S	S
Sawyer	M	SL	SL	H	H	M	S	SL	M	M	M
Trinity	S	SL	SL	VH	L	S	S	SL	M	S	S
Class III Series											
Acadia	M	SL	SL	H	M	S	S	SL	S	M	M
Austin	S	M	S	H	L	S	S	S	S	S	S
Axtell	S	SL	SL	H	M	S	S	SL	S	S	S
Bowie	M	M	M	M	H	M	M	M	S	M	M
Burleson	S	SL	SL	H	L	S	S	SL	M	S	S
Caddo	S	SL	SL	H	H	S	S	SL	M	S	S
Crockett	S	SL	SL	H	L	S	S	SL	M	S	S
Garner	S	SL	SL	VH	M	S	S	SL	M	S	S
Krivin	S	M	M	H	M	M	S	M	S	S	M
Ruston	SL	M	M	L	M	SL	SL	M	S	SL	SL

Table 39. Continued

Soil Classes and Series	Highway location	Small reservoirs	Excavated ponds (runoff fed)	Corrosivity - uncoated steel	Corrosivity - concrete	Foundations for low buildings	Septic tank filters	Sewage lagoons 0 to 2% slopes	Sewage lagoons 2 to 5% slopes	Streets and low cost streets	Light industry
Class IV Series											
Cuthbert	S	M	M	M	H	M	S	SL	M	S	M
Eddy	S	S	S	H	L	M	S	S	S	M	M
Ellis	S	SL	SL	H	L	S	S	SL	M	S	S
Navasota	S	SL	SL	VH	H	S	S	SL	M	S	S
Wrightsville	S	SL	SL	VH	H	S	S	SL	M	S	S
Wilson	S	SL	S	VH	M	S	S	SL	M	S	S
Houston Black	S	SL	SL	VH	SL	S	S	SL	M	S	S
Houston	S	SL	SL	H	L	S	S	SL	M	S	S
Byars	S	SL	S	H	H	S	S	SL	M	S	S
Class V and VI Series											
Bub	S	US	S	M	M	M	S	S	S	S	M
Lakeland	SL	S	S	L	H	M	SL	S	S	SL	M

*Limitations established by the Soil Conservation Service (USDA). S-severe; SL-slight; US-unsuitable; M-moderate; H-high; VH-very high; L-low.

Table 40. First alternate land use with secondary land uses expressed in terms of desirability for each soil series.

Soil Class and Series	First Alternate Land Use	Desirability of Secondary Alternate Land Uses Most	Least
Class II Series			
Alto	Wildlife	Recreation	Pasture
Kaufman	Wildlife	Recreation	Pasture
Sawyer	Wildlife	Recreation	Pasture
Trinity	Wildlife	Recreation	Pasture
Class III Series			
Acadia	Woodland	Wildlife	Recreation
Austin	Wildlife	Range	Pasture
Axtell	Wildlife	Pasture	Woodland
Bowie	Wildlife	Woodland	Recreation
Burleson	Range*	Wildlife	Woodland
Caddo	Woodland	Wildlife	Pasture
Crockett	Wildlife	Woodland	Pasture
Garner	Wildlife	Woodland	Pasture
Kirvin	Wildlife	Recreation	Pasture
Ruston	Wildlife	Recreation	Pasture
Class IV Series			
Cuthbert	Wildlife	Woodland	Recreation
Eddy	Wildlife	Range	Pasture
Ellis	Wildlife	Range	Pasture
Navasota	Wildlife	Woodland	Recreation
Wrightsville	Wildlife	Woodland	Pasture
Wilson	Wildlife	Range	Woodland
Houston Black	Wildlife	Range	Woodland
Houston	Wildlife	Pasture	Woodland
Byars	Wet Wildlife**	Woodland	Row Crops
Class V and VI Series			
Bub	Woodland	Wildlife	Pasture
Lakeland	Wildlife	Woodland	Pasture

*Range is defined as unimproved pasture land.
**Wetland-wildlife such as ducks and geese.
Source: Soil Conservation Service

Table 41. Principal tree species found or recommended for planting on each soil series.

Soil Class and Series	Major Species Present or Recommended for Planting
Class II	
Alto Kaufman Sawyer Trinity	*For all Series*: cottonwood (*Populus deltoides*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), slash pine (*Pinus elliotti*), and loblolly pine (*Pinus taeda*).
Class III	
Acadia Austin Axtell Bowie Burleson Caddo Crockett Garner Kirvin Ruston	*Acadia and Caddo*: loblolly pine (*Pinus taeda*), and sweetgum (*Liquidambar styraciflua*),. *Bowie and Kirvin*: loblolly pine (*Pinus taeda*). *Axtell*: post oak (*Quercus stellata*). *Garner*: loblolly pine (*Pinus taeda*) and slash pine (*Pinus elliotti*).
Class IV	
Cuthbert Eddy Ellis Navasota Wrightsville Wilson	*For these series*: loblolly pine (*Pinus taeda*), slash pine (*Pinus elliotti*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), cherrybark oak (*Quercus falcata* var. *pagodaefolia*), green ash (*Fraxinus pennsylvanica*), sycamore (*Platanus occidentalis*), and yellow poplar (*Liriodendron tulipifera*).
Houston Black Houston Byars	*For these series*: cottonwood (*Populus deltoides*), willow (*Salix sp.*), and water tupelo (*Nyssa aquatica*).
Class V and VI	
Bud Lakeland	*For these series*: slash pine (*Pinus elliotti*), loblolly pine (*Pinus taeda*), and shortleaf pine (*Pinus echinata*).

Source: Soil Conservation Service.

Soil capability class II: these soils have moderate limitations that reduce the choice of vegetation that can be grown on them. These soils require moderate conservation practices usually due to erosion or water hazards. The principal soils in this class are the Alto, Kaufman, Sawyer, and Trinity.

Soil capability class III: these soils have severe limitations that reduce the choice of vegetation that can be grown on them due to erosion, water hazards, shallowness, stoniness, or droughty conditions. These soils require special conservation practices to overcome these limitations. The principle soils in this class are Acadia, Austin, Axtell, Bowie, Caddo, Crockett, Garner, Ruston, Kirvin, and Burleson series.

Soil capability class IV: these soils also have severe limitations that reduce the choice of vegetation that can be grown on them and require careful land management. The principal soils in this category include Cuthbert, Eddy, Ellis, Houston Black, Houston, Navasota, Wrightsville, Wilson, and Byars series.

Soil capability classes V and VI: due to similarities of soils within these two classes, they have been grouped. Class V soils are subject to little or no erosion, but have other limitations in the form of acidity and poor drainage. Class VI soils have similar limitations that usually make them unsuited for cultivation. For these reasons these soils are usually considered for pasture, range, woodlands, or game food and cover areas. Examples of these include the Bub and Lakeland series in the Trinity River Basin.

ENVIRONMENTAL IMPACT ANALYSIS

The following series of matrices present the findings of the on-site inspection of the impact zones of the thirteen watersheds. Each quadrangle reviewed is keyed to map numbers used by the Texas Forest Service. From the field findings of the hydrosphere, land use, lithosphere, and biosphere a final impact rating was determined for each study transect and watershed represented (Tables 42 and 43).

Table 42. Total watershed area, transect area, field checked area, and overall impact ratings for the thirteen study watersheds.

Watershed Name	Total Area (acres)	Transect Area (Acres)	Percent of Total	Field Checked (acres)	Percent of Total	Overall Impact Rating
Five Mile Creek	31,600	9,600	30.38	1,192	3.77	- 3
Walker Creek	15,500	9,600	61.94	1,192	7.69	- 3
Bois d'Arc Creek	17,200	9,600	55.81	1,192	6.93	+ 3
Indian Creek	61,000	9,600	15.74	1,192	1.95	+ 3
Blue Lake	2,800	2,800**	100.00	1,192	42.57	+ 3
Cedar Lake Slough	42,300	9,600	22.69	1,192	2.82	+ 3
Cedar Branch	3,400	3,400	100.00	1,192	35.06	+ 3
Hurricane Creek	66,500	9,600	14.44	1,192	1.79	- 6
Busch Slough & Beaver Dam Marsh	29,200	9,600	32.88	1,192	41.10	- 3
Black & White Oak Creek	4,400	4,400	100.00	1,192	27.09	+ 3
Big Creek	59,100	9,600	16.24	1,192	2.02	- 3
Menard Creek	104,000	9,600	9.23	1.192	1.15	- 3
Gaylor Creek	62,100	9,600	15.46	1.192	1.92	+ 6
TOTALS	499,100*	106,600***	21.36	15,496****	3.10	---

*Represents 14.64% of the total 5,328 square miles of watershed area investigated.
**Where transects were larger than total watershed only that portion covered was used.
***Represents 3.13% of the total 5,328 square mile Trinity River Basin.
****Represents 0.45% of the total 5,328 square mile Trinity River Basin.

Table 43. Amount of acreage within each rating classification for the thirteen study watersheds.

Rating	Acres	Net Acres	Percent of Rating Total
- 3	239,400	108,300	41.06
- 6	66,500	4,400	6.62
- 9	---	---	---
+ 3	131,100	---	---
+ 6	62,100	---	---
+ 9	---	---	---
TOTALS	499,100	112,700	22.57*

*Of the 499,100 acres in the thirteen watersheds studied, 362,197 acres would have a minus rating of some type and 136,903 a plus rating of some type.

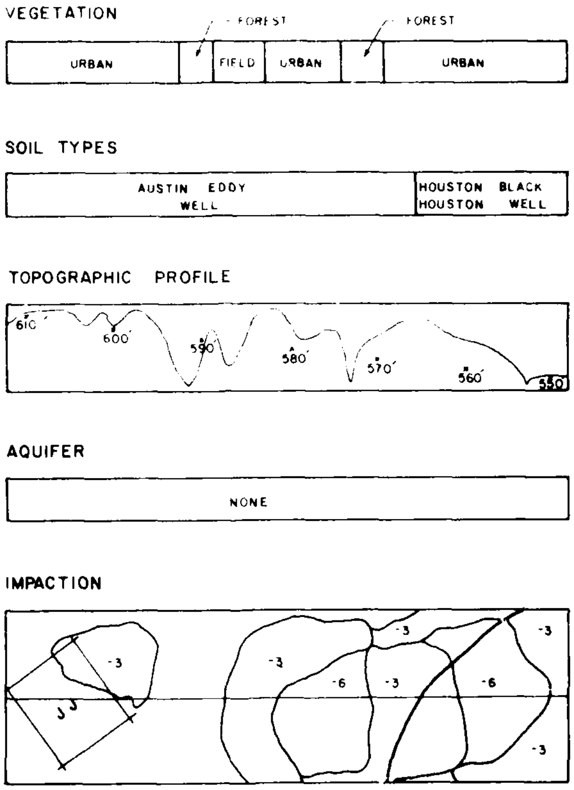


Figure 40.

FIVE MILE CREEK
QUADRANGLE SHEET NO. 752
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S. CLARK, J. JONES, AND
J. WARD

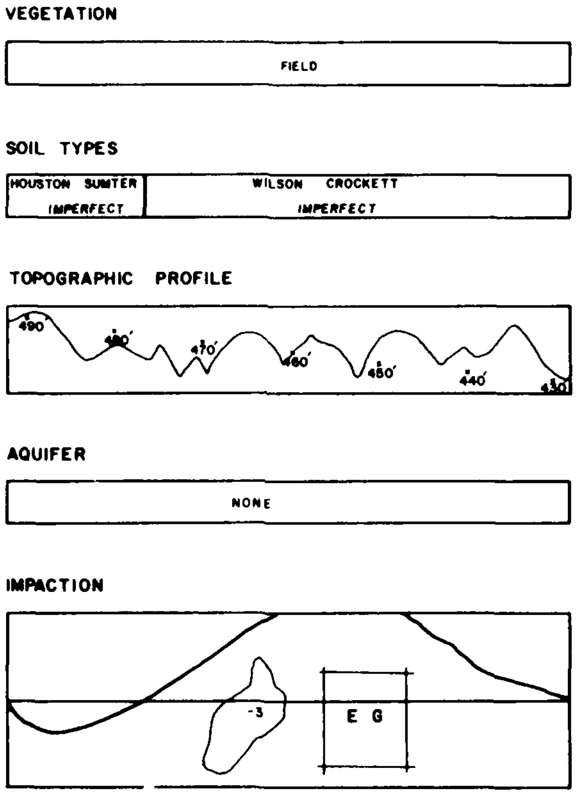


Figure 41.

WALKER CREEK
QUADRANGLE SHEET NO. 106
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S CLARK, J. JONES, AND
J. WARD

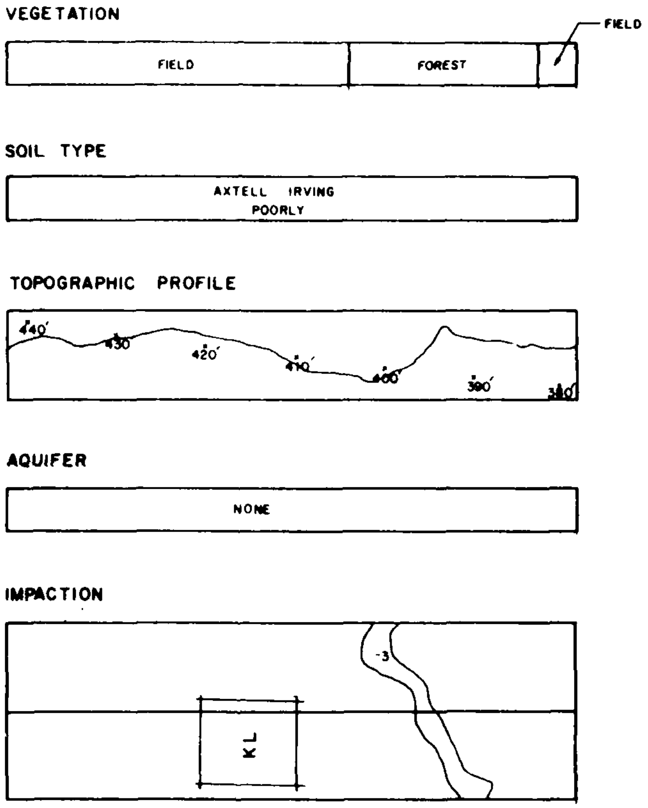


Figure 42.

BOIS D' ARC CREEK
QUADRANGLE SHEET NO. 008
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S CLARK, J. JONES, AND
J. WARD

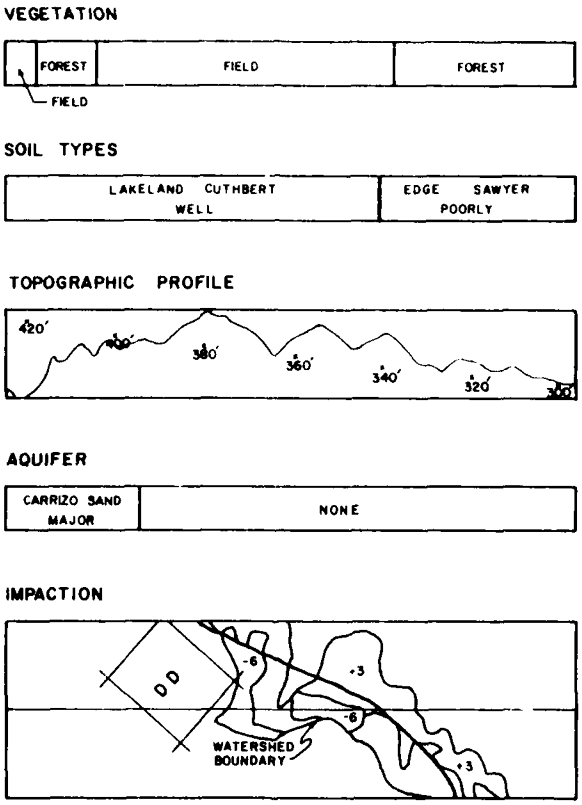


Figure 43.

INDIAN CREEK
QUADRANGLE SHEET NO 463
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S. CLARK, J. JONES, AND
J. WARD

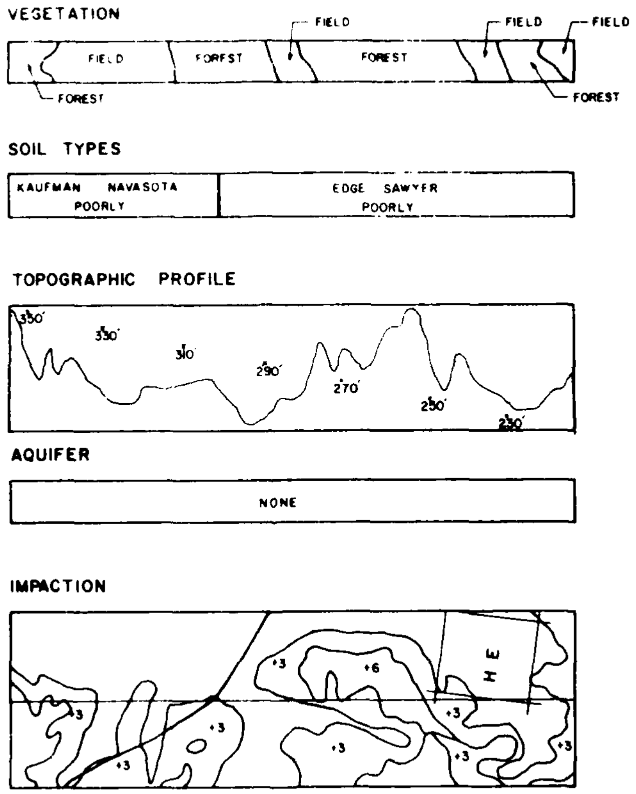


Figure 44.

BLUE LAKE
QUADRANGLE SHEET NO 464
STEPHEN F AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY S CLARK, J JONES, AND
J WARD

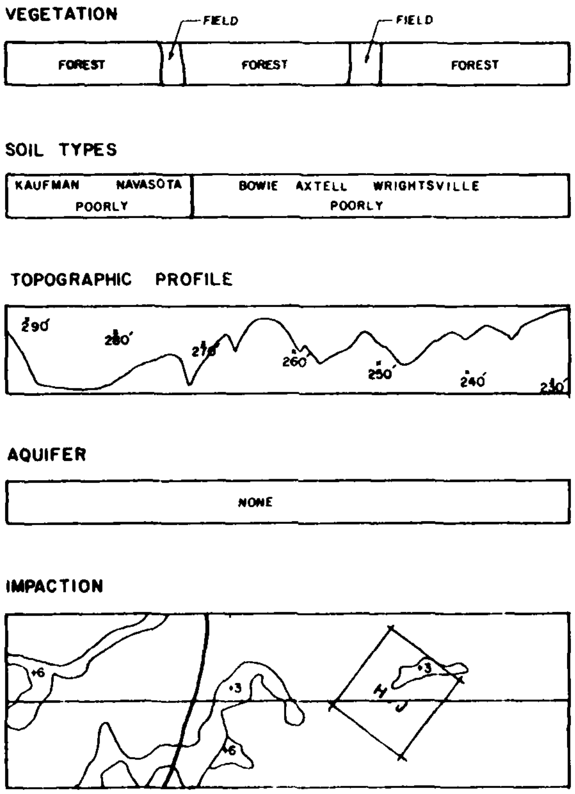


Figure 45.

CEDAR LAKE SLOUGH
QUADRANGLE SHEET NO 465
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY S. CLARK, J JONES, AND
J WARD

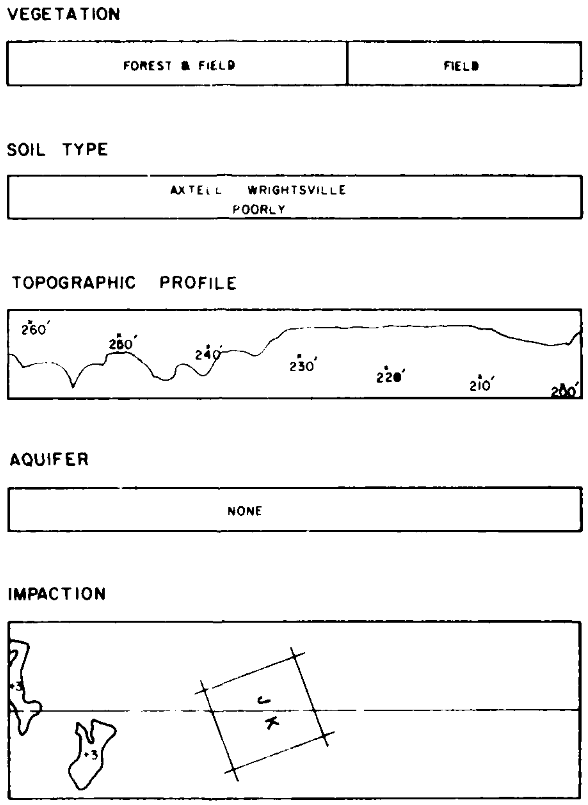


Figure 46.

CEDAR BRANCH
QUADRANGLE SHEET NO 616
STEPHEN F AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY S CLARK, J JONES, AND
J WARD

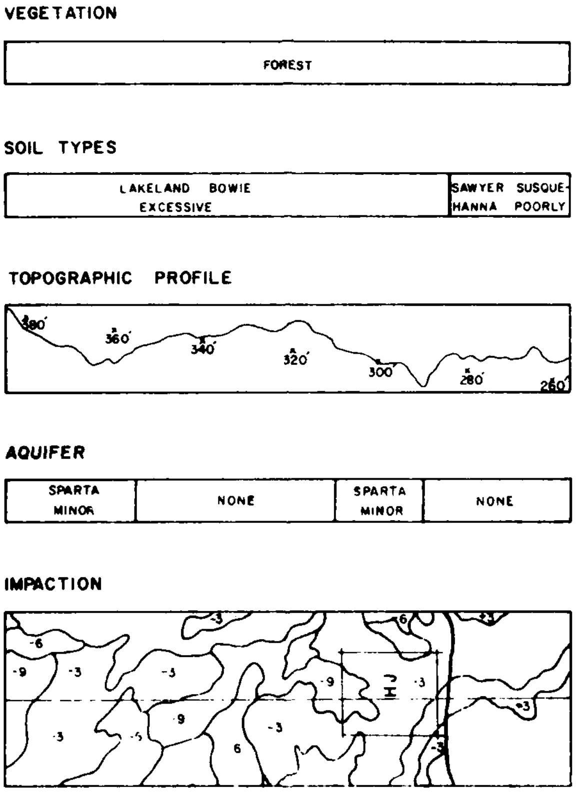


Figure 47.

HURRICANE BAYOU
QUADRANGLE SHEET NO. 668
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S. CLARK, J JONES, AND
J. WARD

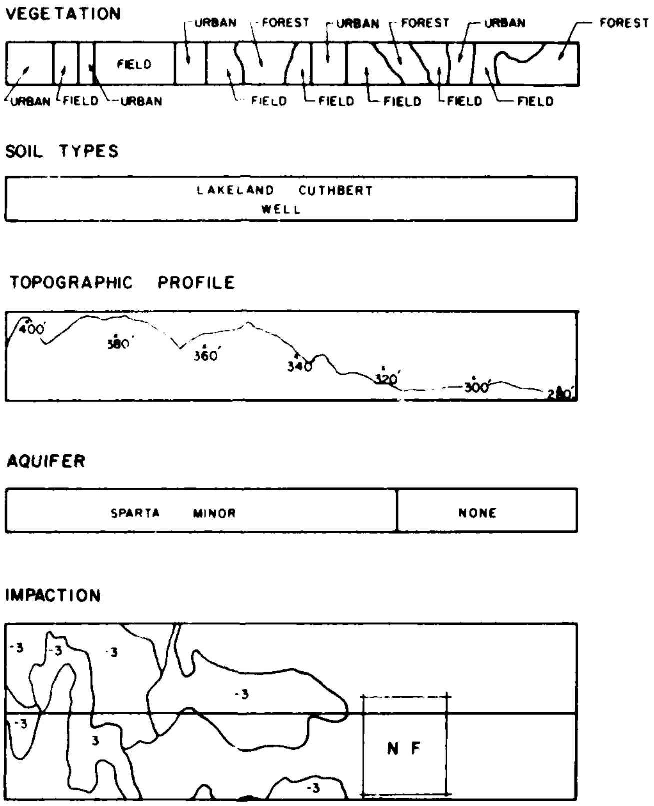


Figure 48.

BUSCH SLOUGH AND BEAVER DAM
QUADRANGLE SHEET NO. 665
STEPHEN F AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY S CLARK, J JONES, AND
J. WARD

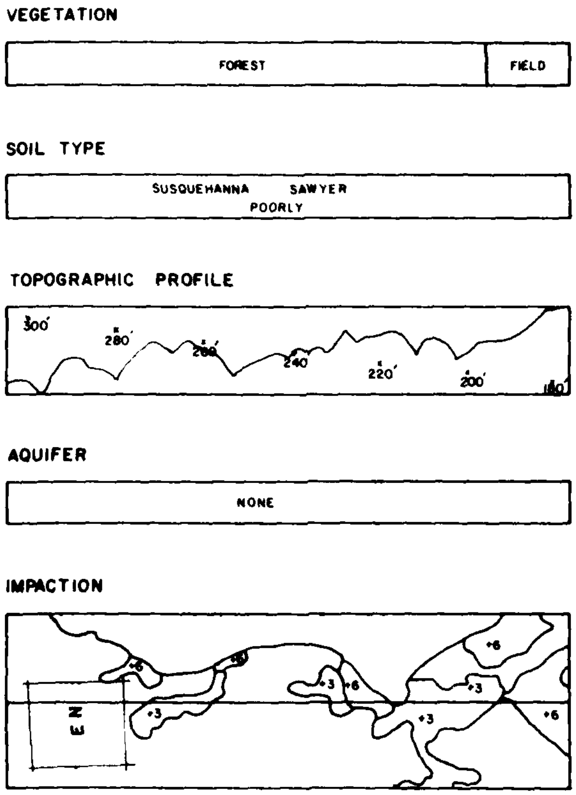


Figure 49.

BLACK AND WHITE OAK CREEK
QUADRANGLE SHEET NO. 067
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S. CLARK, J. JONES, AND
J. WARD

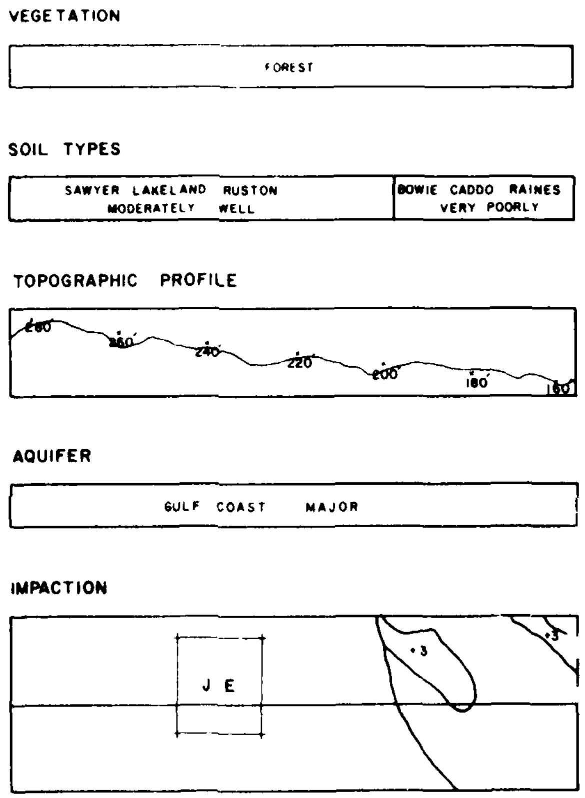


Figure 50.

BIG CREEK
QUADRANGLE SHEET NO 274
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S CLARK, J JONES, AND
J. WARD

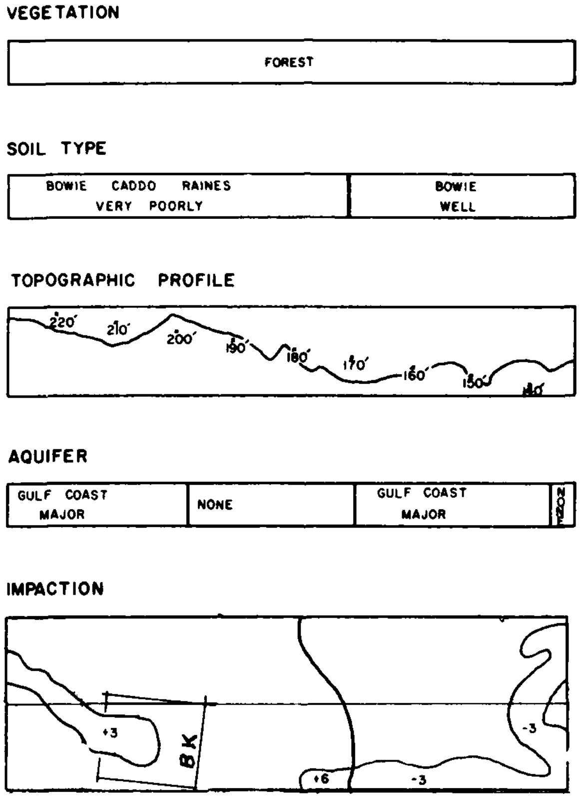


Figure 51.

MENARD CREEK
QUADRANGLE SHEET NO. 277
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S. CLARK, J. JONES, AND
J. WARD

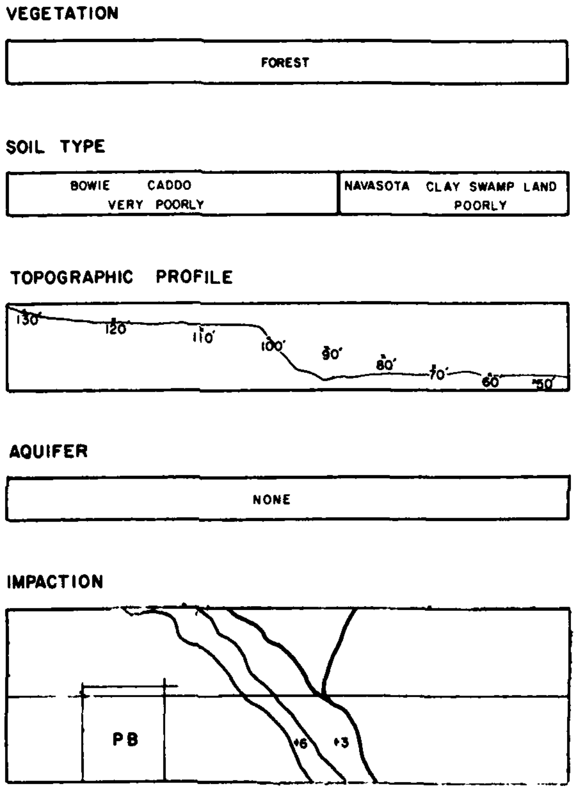


Figure 52.

GAYLOR CREEK
QUADRANGLE SHEET NO 376
STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY
DRAWN BY: S. CLARK, J. JONES, AND
J. WARD

SUMMARY

A reconnaissance level inventory of soil capability and forest hydrology in relation to watershed management and land use planning is presented for the upper (Dallas-Fort Worth to Tennessee Colony), middle (Tennessee Colony to Lake Livingston), and lower (Lake Livingston to Wallisville) sections of the Trinity River. The data reflect the capability of the land for watershed management and land use planning based on ecological considerations. This study should only be considered at the regional level for presenting alternate considerations and does not substitute for more detailed investigations at county and local levels where the choice of management and use alternatives should occur.

In the thirteen watersheds studied, encompassing 5,328 square miles, available data on several environmental strata were assembled. Data are presented in patterns so that interrelationships can be seen. New patterns will evolve due to the channelization of the river and will be reflected in land use changes.

The use of impact zones was employed to express considerations of various land uses and vegetation management.

CONCLUSIONS

It is concluded that at least 50 percent of negative impact identified in this report can be mitigated and even reversed by wise land use management. A major conclusion drawn is that the three portions of the river are different in nature of land use, vegetation, and watershed character. As a result, a different set of planning rules must be considered for each section. There are some considerations that apply equally to all parts of the river--upper, middle, and lower:

<u>In areas of greatest impact (minus nine zones)</u> -
. . .Lack of water in or on the soil will interfere with and may even disrupt plant growth and cultivation.
. . .Transition may occur over long periods of time (10 years plus) from existing tree species to those common in upland areas.
. . .Natural reproduction of present tree species will be hampered.
. . .Present grazing and farming practices may have to be reduced in intensity, especially in the upper portions of watersheds, where soil moisture may decrease.

. . .Erosion hazards may increase, especially on more susceptible soils, where stream base gradients are changed.

In areas of greatest positive impact (plus nine zones) -
. . .Increased drainage will change vegetation significantly to higher value upland species.
. . .Areas previously too moist for use will find increased value as residential and recreation sites.

In areas of medium impact (minus six zones) -
. . .The limiting factor of soil moisture will be similar, but less than in areas of greatest impact.
. . .A medium risk of erosion is present unless a plant cover is maintained.
. . .Natural reproduction of tree species may be hampered.
. . .Farming and grazing will be restricted during periods of prolonged drought.
. . .A permanent condition of decreased soil moisture will be established with some fluctuation of the water table.
. . .Recreation and agriculture use of watersheds can directly pollute the channel via unchecked sewage disposal drainage directly into the water table and surface runoff of fertilizer from improved pastures.

In areas of medium positive impact (plus six zones) -
. . .Increased drainage will change vegetation to somewhat higher valued upland species.
. . .Increase the intensity of cultivation and grazing due to drier conditions.
. . .Areas will increase in value as recreation and residential sites.

In areas of minor impact (minus three zones) -
. . .Lack of water may interfere with plant growth only after prolonged drought periods.
. . .Fluctuations in water table will depend upon the interrelationship between the channel and precipitation.

In areas of minor positive impact (plus three zones) -
. . .Increased drainage will change vegetation very little except during prolonged droughty periods.
. . .Areas previously stagnant may become valuable for wetland wildlife.

In general there are certain major conclusions that can be drawn about the land uses within each section of the river:

Upper Section (Dallas-Fort Worth to Tennessee Colony): The upper section with the exception of industrial, commercial, and residential growth near the Dallas-Fort Worth area will experience the least amount of land use change in the entire basin. This region is mostly in agricultural uses that depend upon precipitation and not the river for maintenance.

Middle Section (Tennessee Colony to Lake Livingston): The middle section will probably have the least amount of land use change of any total section of the river. The only area that will change is that at the head of Lake Livingston, and this change is already taking place. Some of the low grade hardwood lands will be converted to pasture and may increase the amounts of animal waste and fertilizer being washed into the channel and reservoir. Due to the lack of population pressures this section will retain much of its present land use pattern for the next ten to twenty years.

Lower Section (Lake Livingston to Wallisville): The lower section, especially below Lake Livingston to Liberty will experience the greatest amount of land change in the entire river basin. Already, areas of higher ground in the bottom are being converted to pastures and residential areas. This will continue with the increased population growth of the Houston-Beaumont areas. The increased drainage and better flood control factors of the new channel will enhance these developments. It is this section that will have the greatest need for watershed management and land use zoning to protect the resources and water qualities of the river and channel.

RECOMMENDATIONS

It is recommended that:

. . .detailed watershed conservation and land use plan be prepared for the area immediately adjacent to the reservoir and channel. Some components of the investigation would be forest communities, land use, land use intensity, land ownership, land ownership profile, and present and future uses of created oxbows.

. . .land management programs of federal and state governments focus on the conservation problems of the watersheds, especially in the upper sections of those most susceptible to erosion. A choice of conservation practices should be provided for each landowner. Water resources for local community needs should be investigated.

. . .the study area be used as a national laboratory for the development and testing of conservation practices and land use changes that can greatly mitigate any negative impact caused by the channel or reservoir construction.

. . .well defined transects be established and a land use profile be developed showing a complete history of past and present land use, rates of change over a period as far back as records will allow, and projected forward into the future for 10 to 20 years.

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Maps:

Geological

Geologic Atlas of Texas
Bureau of Economic Geology
University of Texas
Austin

Highway

County Road Map Series
Texas Highway Department
Austin

Soil

General County Soil Map Series
U. S. Department of Agriculture
Soil Conservation Service
Temple and Nacogdoches

Topographic

Quadrangles, U. S. Geological Survey
Texas Water Development Board
Austin

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